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VOL. XXXVII. — No 3. MARCH 1960.

Monthly Bulletin of the International Railway Congress Association

(English Edition)

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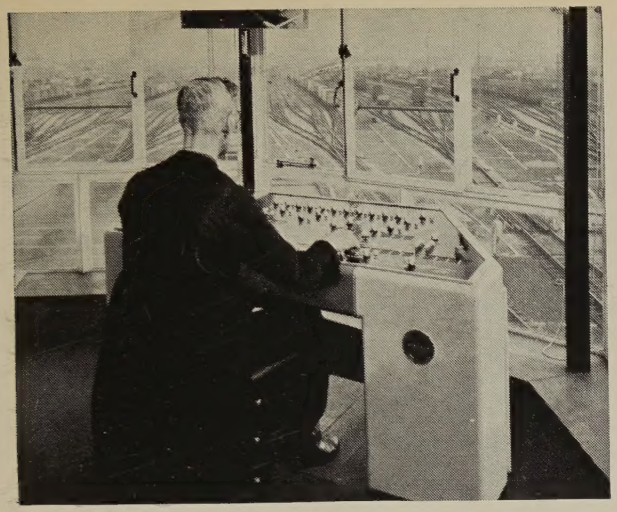

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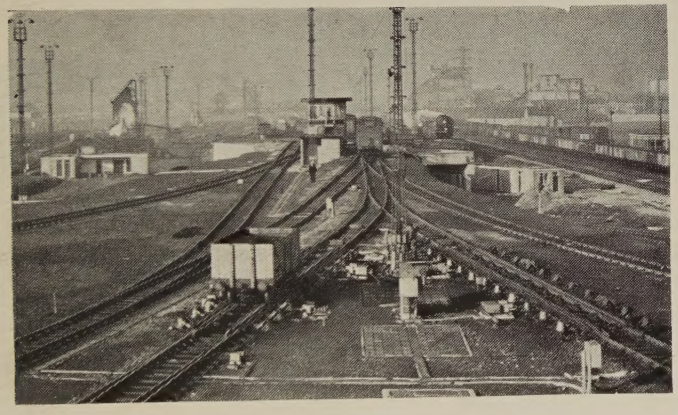

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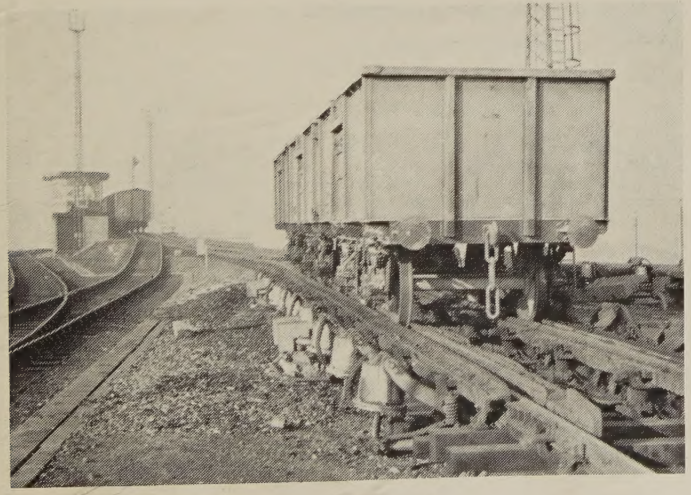

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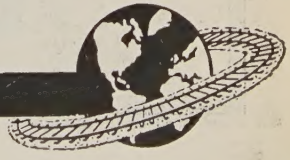

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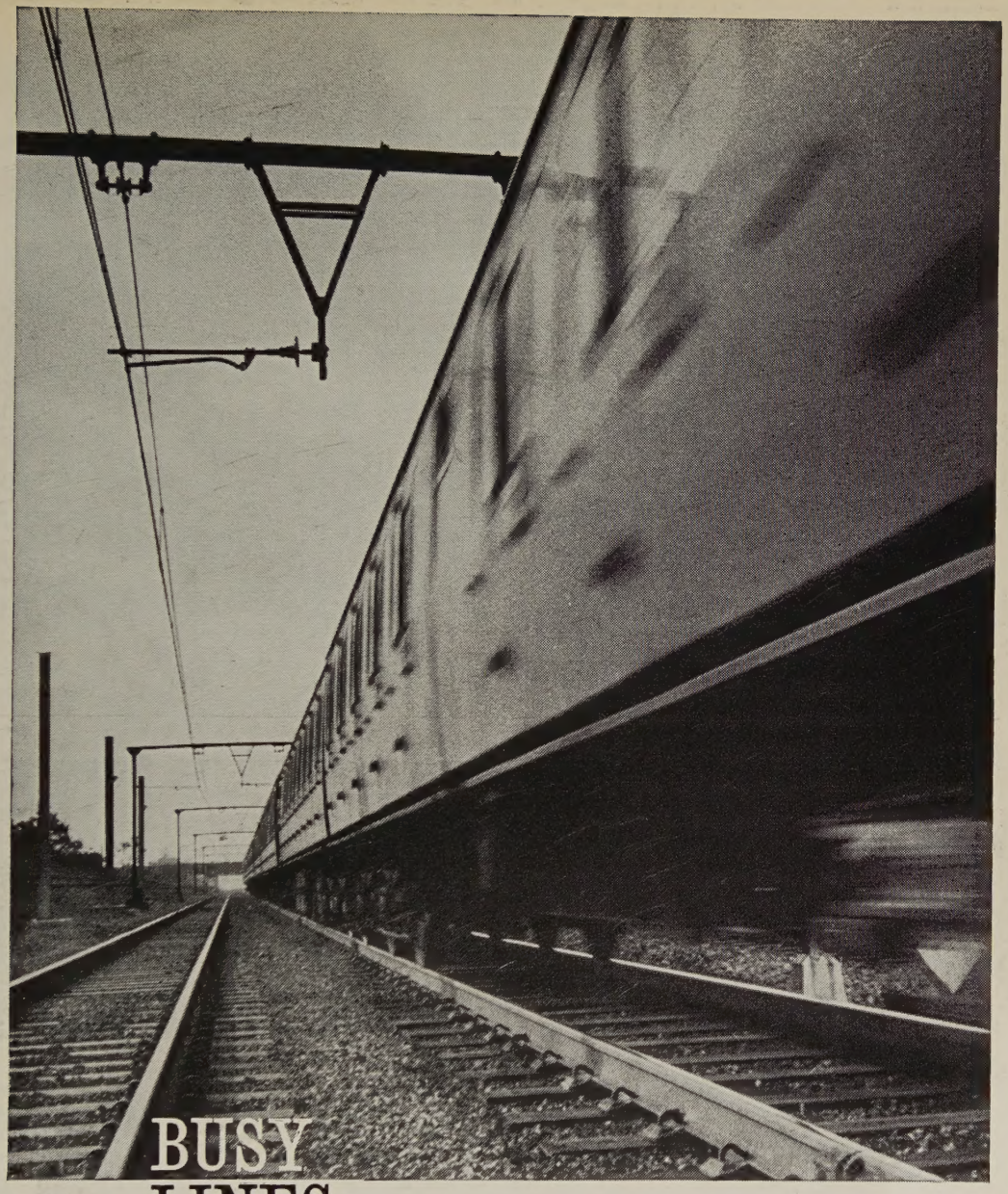

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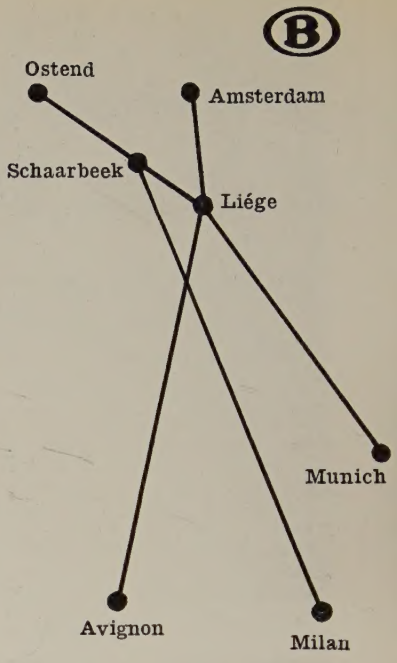

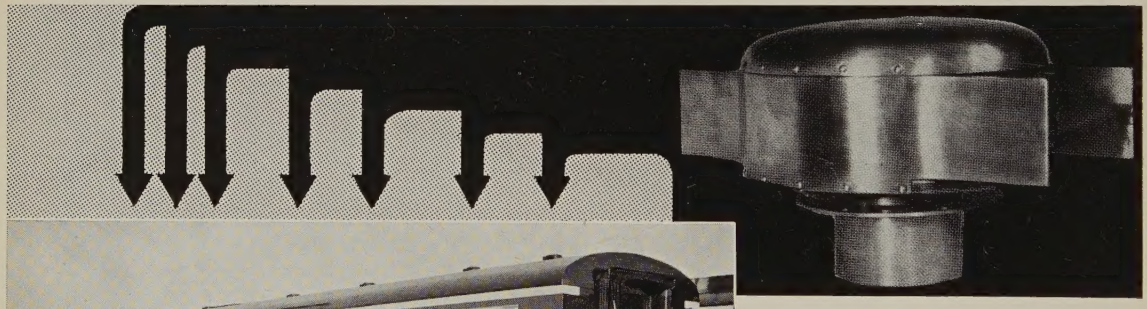

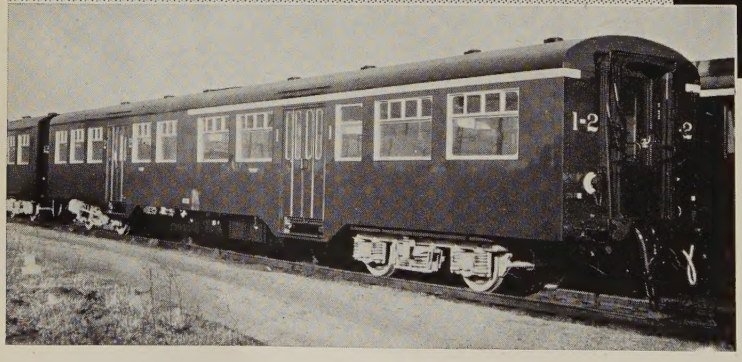

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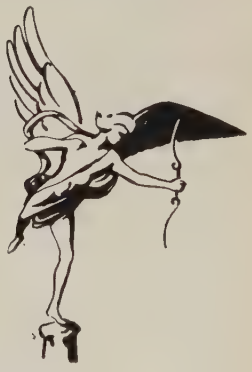

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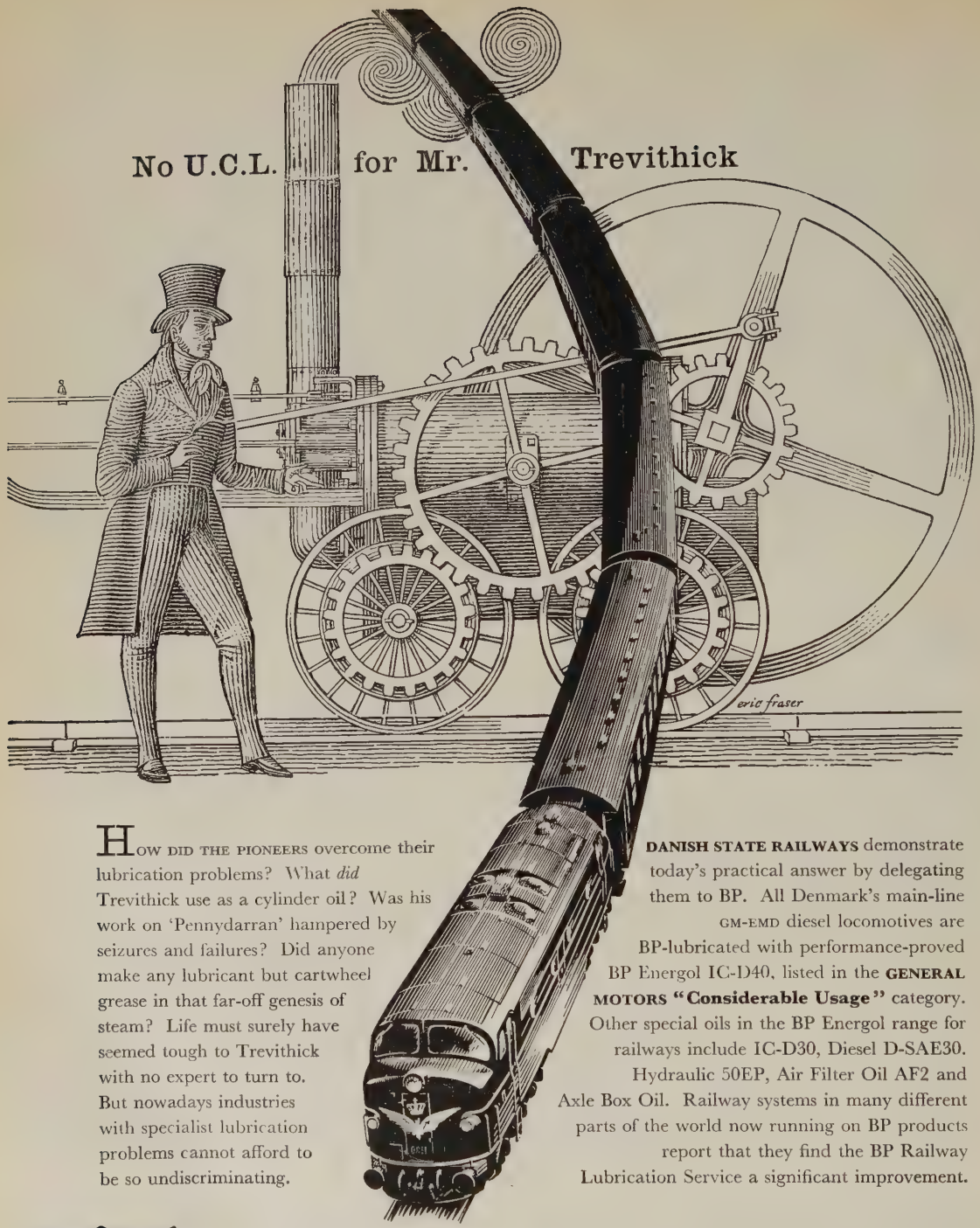

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

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Advertisements : All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels**.

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An edition in French is also published.

Vol. XXXVII. — No. 3. March 1960.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[385 .58]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(BRUSSELS, 1960).

QUESTION 4.

What steps can be taken to develop and maintain co-operation between management and staff to improve productivity?

What scope is there for work study and incentive schemes?

REPORT

(Austria, Belgium and Belgian Congo, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia),

by E. M. Arys,

Inspecteur Principal
à la Direction du Personnel et des Services Sociaux de la Société Nationale des Chemins de fer Belges.

The Enlarged Meeting of the Permanent Commission to be held in Brussels in 1960 has as item 4 of its agenda the following question :

« What steps can be taken to develop and maintain co-operation between management and staff to improve productivity ?

» What scope is there for work study and incentive schemes ? »

This study was the subject of a single questionnaire drawn up in collaboration by the two reporters for the French and English speaking countries respectively. The French questionnaire was sent to 63 Railway Administrations.

A number of Administrations, whilst recognising the interest they had in this question, regretted that they were not in a position to supply any information of sufficient use for its study.

The information developed below is based on the replies received from the :

— Danish State Railways;
— Spanish National Railways (R.E.N.F.E.);
— French National Railways (S.N.C.F.);
— Italian State Railways (F.S.);

— Benguela Railways;
— Swiss Federal Railways (C.F.F.);
— Emmental-Burgdorf-Thun Railways;
— Jugoslavian Railways;
— Belgian National Railways (S.N.C.B.);
— Hungarian State Railways.

We wish to convey our most grateful thanks to all the above Railways for their co-operation.

* * *

PRODUCTIVITY FORMULAE.

I. — A. 1. General.

Researches into measures likely to develop and maintain co-operation between the management and the staff in order to increase productivity, imply, logically, first of all the job of getting out formulae to measure productivity, which are both valid and easily comprehensible by the staff.

It would appear essential, with this object in view, to consider the idea of the overall productivity of the system, and that of the productivity of the sections.

In effect, the interest of the staff should have a double objective :

1) interest in the general running of the undertaking;

2) interest in that section of the undertaking with which they are connected.

The majority of Administrations are experimenting with productivity on the « system » level, but four of them (F.S., Emmental Rys, Jugoslavian Rys and S.N.C.B.) are also considering the productivity indices for certain groups of activities at lower levels.

From the point of view of the system, the indices relate above all to the productivity of the work, the productivity of the power, the productivity of the motor stock, and the productivity of the rolling stock considered either as a whole or for each of these two categories : passenger and freight.

The formula dealing with labour is in relation to the number of traffic-units, either the labour units (R.E.N.F.E., Jugoslavia Rys), or the hours of work, the product of the labour available and the statutory working hours (S.N.C.F.), or the real time on the work, i.e. after deducting holidays, time off, absences for accidents, illness (C.F.F.).

The formula relating to the power productivity expresses the ratio between the number of traffic-units and the overall traction power consumption expressed in coal equivalents.

The formula relative to the productivity of the motor stock expresses the ratio between the number of traffic-units and the pondered number of traction units in service (S.N.C.B. and R.E.N.F.E.).

The Jugoslavian Rys take as their productivity index for the motor stock the number of t/km, train/km or locomotive/km.

The productivity of the rolling stock is determined, especially in Spain and in France, according to its nature, by formulae relating to the number of traffic-units, either to the number of seats offered, or the number of vehicles in service.

The S.N.C.F. determine the productivity of the four factors which affect production (labour, power, traction units and rolling stock) by establishing a percentage of economy or surplus obtained compared with the reference period (year 1955).

« The surplus (B) is obtained by comparing, for each means of production, the necessary averages (M) calculated on the basis of the productivity of 1955 compared with the averages effectively used (m) :

$$B = \frac{M - m}{m}$$

» The necessary production averages (M) are given by a linear formula which includes a fixed part and a part which is proportional to the production ($a + b\,VK + c\,TK$).

» The production is not, in fact, entirely proportional to the averages used; a part

of these averages is independent of the traffic.

» The economy due to the productivity is determined :

» — as far as the staff is concerned, by applying the surplus obtained under this heading to the labour costs (direct costs without charges);

» — as far as the power is concerned, by applying the corresponding surplus to the cost of the traction power consumption;

» — as far as the traction and rolling stock is concerned, by applying the surpluses to the maintenance costs increased by the sinking fund charges for the stock.

» The increase in productivity being due in part to the capital invested, from the savings calculated in this way are deducted the financial charges since 1955, in order to obtain the net saving.

» Monetary factors are not set aside since the surplus for each factor of production is related to the annual cost, in order to determine the net saving which the increase in productivity has made it possible to realise. »

Most of the other railways do not allow any inclusion of monetary factors in their formulae.

They are unanimous in recognising that the monetary factor is too sensitive to fluctuations due to factors outside the operation of the system.

I. — A. 2.

a) Only two Administrations (Benguela and Emmental Rys) report the existence on their railways of organisations dealing directly with questions of productivity. It appears to us, however, that these organisations are no other than departments for the study and preparation of the work like those met with in certain departments of the large railways.

Three railways (F.S., R.E.N.F.E., and Jugoslavian Rys) are considering setting up such organisations.

Italy explains the reason for so doing by the need to find some better method of setting and solving productivity problems by making the organisation in question responsible for co-ordination as regards methods of work, supervision, etc.

At the same time, the same duties, in connection with the management of the departments, will be centralised in organisations for this purpose.

Most of the other railways, and in particular the S.N.C.F. and F.S., make the point that in the absence of any special organisation, questions of productivity must concern all grades, .or that they must be controlled and co-ordinated by each department, for its own sphere.

On the S.N.C.F., there is, however, in the higher grades a General Studies Management (to which the Operational Research Department is attached) which programmes, co-ordinates and controls the problems of productivity in close collaboration with the managements of the Accounts, the Staff, Rolling Stock and Traction, Fixed Installations and Traffic Departments.

b) The replies to this question should eventually contribute towards justifying the constitution of special organisations. Those, which we received, did not do so.

c) In the case of the Benguela Rys, the special organisations have not yet achieved the objective assigned to them, whilst according to the Emmental Rys, the reply is in the affirmative.

As a consequence, the Benguela Rys propose :

— to improve the preparation and professional training of all the shop staff;

— to interest the staff personally in increasing productivity.

According to the S.N.C.F., the organisation of productivity on their system would appear to be satisfactory.

The increase in productivity in combination with other means has enabled many

systems to reduce their labour force during the last five years. We may quote as an example the figures given by the following railways :

S.N.C.F. : 30 000;

S.N.C.B. : 3 700 (8 800 during the last six years);

Danish : 1 500 units approximately;

Benguela :

2 % in the case of the European staff;
17.70 % in the case of labourers (it should be noted, however, that the figures for African employees have increased by 5 %);

Emmental :

6 % in the case of the station staff;
5 % in the case of the train staff.

d) No replies were received.

e) The S.N.C.F. and Jugoslavian Rys are in direct contact with the National Productivity Office. The S.N.C.F. maintains permanent relations with the General Productivity Authority on which it has representatives. The Jugoslavian Rys collaborate with the National Office through its « Organisation and Productivity » sections.

I. — B. 1. Collaboration between Management and Staff.

The part played by the human factor in all programmes for increasing productivity.

All the Administrations are unanimous in recognising that the human factor plays a primordial part in increasing productivity.

Without the confident collaboration of the staff, rationally trained for their new duties and new techniques, programmes for increasing productivity can never be fully realised, no matter what material means and techniques are introduced.

Experience has shown in effect, that a passive attitude on behalf of the staff can not only retard but even prevent any increase in productivity which is otherwise technically possible.

I. — B. 2.

a) *Initiation of the staff into the principles of productivity.*

The staff is initiated into the principles of productivity :

— through the usual grades (S.N.C.F., R.E.N.F.E., S.N.C.B.);
— by professional journals published by the Administrations themselves (Danish Rys, S.N.C.F., C.F.F., F.S.);
— by instructors selected from the most suitable employees for this duty (Benguela Rys);
— by systematic educational courses (C.F.F., Jugoslavian, F.S. and Emmental Rys).

b) *Objectives to be attained. Information given to the staff.*

The C.F.F., S.N.C.F., S.N.C.B., R.E.N.F.E., F.S. and Emmental Rys, in order to keep the staff informed of the objectives in view, make use of the following methods for their initiation into the principles of productivity.

The S.N.C.B. also keeps the professional organisations informed, whereas on the S.N.C.F. the representatives of the staff on the mixed committees (joint committees on staff, districts, regional services or technical managements) are kept informed of projects intended to improve productivity and the repercussions these may have upon the staff (effects on numbers and grades; altering or re-classifying the staff; improving working conditions; increased output bonuses).

The methods followed by the other Administrations differ to some extent :

the Danish Rys inform the arbitration committees of any productivity problems that have to be solved:

in Jugoslavia, the staff is kept informed by the reports of units of the labour office, worker's councils, management committees, the press, and also by communications put out at meetings;

in Benguela, the objectives aimed at as regards productivity are communicated by the heads to those immediately below them.

c) the few replies received did not allow of any clear idea being formed on this point.

I. — B. 3.

a) *Atmosphere of confidence to be created and encouraged.*

Once the staff has been instructed in the principles and consequences of productivity, they must be won over in favour of it by creating an atmosphere of confidence.

The question naturally arises not only how this can be done, but how its subsequent development can be encouraged.

It would appear that such a result can be obtained :

— by giving the staff very full details concerning modernisation programmes and the progress made in carrying these out. The staff will be more interested in such programmes if they are accompanied in general by improvements in working conditions and a parallel increase in wages due to the consequences of productivity;

— by concentrating on propitious themes in the instructions for this purpose, in lectures for the staff, in the technical press, in notices for the arbitration committees;

— by setting up staff committees in order to increase their interest in the prosperity of the undertaking, to encourage collaboration between the management and the staff, to allow the staff to express their opinions on questions in connection with the general Administration or certain branches of the service;

— by including in the orbit of the labour management certain elements which, in view of their important functions, exercice a considerable influence on the results of the activities of the undertakings;

— by making the staff productivity conscious and giving it guarantees which should protect it from any unfavourable consequences that might result, as far as it is concerned, from an increase in the overall volume of production;

— by endeavouring to obtain the collaboration of the trades unions; by organising at the place of work, meetings between the managerial and executive staff and the workers; by allowing the staff a greater share in the undertaking.

b) *Guarantees to be given to the staff.*

The replies stress the fact that, in general, the railwaymen's statute assures them stability of employment and prevents their dismissal.

They make it clear that in spite of the absence of guarantees on this point, arrangements are always made to avoid or reduce as far as possible any transfer of labour owing to increased productivity.

If necessary, the Administrations endeavour to reclassify those employees whose jobs are done away with as a result of reorganisation measures.

I. — B. 4. Consequences for the staff of increased productivity.

a) *Compatibility of the guarantees given and the re-utilisation of employees becoming redundant owing to increased productivity, and who should therefore be either dismissed or transferred.*

Dismissals.

The statutory staff cannot be dismissed. They are rationally retained in service :

— by limiting engagement of new employees to replace those who retire, die, or are transferred;

— by a progressive and methodical application of suitable measures to speed up productivity according to the rhythm at which employees leave.

Transfers.

Transfers of employees are authorised in all cases.

The carrying out of programmes intended to develop productivity therefore does not guarantee employees against possible transfer. However, they are only transferred when it is found impossible to re-adapt or re-use them in the same place.

The text given under the previous heading « Guarantees to be given to the staff » stresses the obvious sollicitude of most of the Administrations in the case of employees it becomes necessary to consider transferring.

b) *Retaining the whole labour force by intensified manufacture or by manufacturing new products involving at the same time partial re-equipment of the machinery and re-adaptation of the labour which has become available.*

In general, this has not been considered, and the few replies which were received were in the affirmative.

Certain Railways set up accessory or supplementary activities, some of which are of a temporary nature, and others of a permanent nature.

On the S.N.C.B., for example, under such circumstances the manufacture of new products in certain central shops has made it possible :

1) no longer to need to have recourse to private industry in certain cases;

2) to reduce the production in other establishments;

3) to consider centralising these activities and closing down the small establishments.

I. — B. 5.

a) and b) *Collaboration of the trades unions tending to restore an atmosphere of social confidence.*

In Spain, the intervention of the trades unions is regulated by law within the framework of the commission for manufacturing undertakings.

All measures intended to assure that the undertaking will have the collaboration of the latter can therefore only be considered in so far as it complies with this law.

Apart from Denmark, which mentions the setting up of arbitration committees, and Benguela which does not make provision for any collaboration between the company and the trades unions in the field with which we are dealing, all the railway Administrations seek the collaboration of the trades unions.

The latter, in default of any actual productivity organisation, are represented on the organisations dealing with the problems of productivity :

— Administrative Council (S. N. C. F., S.N.C.B., F.S.);

— Mixed Committees and Arbitration Committees (S.N.C.F. and S.N.C.B.);

— Consultative organisation of the Ministry of Transport (F.S.);

It should be noted that in Belgium, on this plane, the employers and the trades unions have shown their desire for complete collaboration by a joint manifesto.

I. — B. 6. Optimum degree of collaboration to be obtained from :

— *suitable professional training;*

— *certain grades specially trained for this purpose;*

— *an improvement in the material working conditions.*

Realisations in these different fields.

The replies mainly dealt with the first and third of these methods.

From the point of view of suitable professional training, they mentioned :

— training the staff in apprenticeship schools;
— systematic supervision of young workmen by instructors;
— systematic training of the staff for their profession and for improving their skill (psychotechnical selection, general training courses, so-called professional training, courses intended to instruct the staff in the new techniques and in modifications to working methods (S.N.C.F.);

The training proposed :
— by the C.F.F. (regular instruction courses under the management of specially qualified officials and optional courses for the shop employees);
— by the Jugoslavian Rys (permanent courses and schools for the advanced training of different specialist railwaymen);
— by the F.S. (instruction or requalification courses for the benefit of various categories of operating and shop employees),

is to some extent similar to the systematic training mentioned by the S.N.C.F.

The S.N.C.F. add in connection with the second method :

« The practical training of officials and foremen is also carried out systematically; for this purpose small work groups are set up and the study sessions are specially devoted to the art of instructing, the art of improving working methods, the art of improving relations in work. Moreover, officials of the three departments (M.T., Ex. and V.B.) (*) of each District meet together at periodical conferences during which the special problems of one department are studied and the effects of these problems on the other departments. »

It should be noted that in the central shops of the S.N.C.B., the foremen are given the same training as that mentioned by the S.N.C.F.

Amongst realisations in connection with material working conditions, mentioned by the S.N.C.F., the Benguela Rys, the C.F.F., the Emmental Rys, the F.S. and the S.N.C.B., most of which are common to all these railways, mention must be made of :

— improving the equipment;
— reorganisation of working points and the siting of the machines;
— rearrangement and modernisation of places of work;
— protecting the workers against risk of accidents;
— installation of cloakrooms, washbasins, showers;
— lounges for the train staff, canteens, rest rooms, libraries, sport facilities;
— issue of hot or cold drinks according to the season;
— organisation of transport for gangs which travel about (lorries, canteens).

I. — C. Keeping the principles of productivity before the staff.

1. *Need for permanent action to maintain a spirit of productivity and collaboration.*

a) The majority of Administrations consider that such action is necessary.

In effect, human nature is such, that constant stimulation is required. However much working methods are improved, the staff may have a tendency to relax their efforts. In addition, all extreme centralisation and specialisation run a risk of dehumanising the work. Hence the importance of human contacts and continued action which is the more justified the more the systems of production have to adapt themselves with flexibility to the undertaking and to social conditions which are in a constant state of evolution.

The S.N.C.F. points out, however, that if such action is necessary, it is also essen-

(*) Rolling Stock, Operating and Permanent Way & Buildings Depts.

tial that psychology is used in carrying it out and a certain discretion, otherwise it might lead to results, the contrary to those desired.

b) Keeping the staff informed.

Results are most often obtained by publications of a professional kind published either by the Administration or by the professional organisations.

The F.S., however, communicate the results directly to the staff when these benefit by a system of inducement money intended to incite them to still greater productivity.

On the Jugoslavian Rys, the results are published in various management reports issued either by the Management or the workers councils, which are communicated to those concerned by various means (meetings, special bulletins, press, notice-boards for this particular purpose).

On the S.N.C.B., in those establishments where the collective interest of the staff in increasing productivity has been introduced, the results are systematically communicated to the men and to the Regional Arbitration Committees concerned.

It appears from the information received that the authenticity of the results is guaranteed in so much as this is necessary, by the fact that they are submitted to the Administrative Councils and to the Arbitration Committees on which the trades unions are represented.

Employees usually are able to comment and criticise.

Most commonly, they can do so through the staff representatives or professional organisations.

I. — D. Interesting the staff in increasing productivity.

1. *By reducing working hours whilst leaving wages unaltered,*

or

By giving the men a pecuniary interest in the matter.

The R.E.N.F.E., the S.N.C.F., the F.S., the Jugoslavian Rys, and the S.N.C.B. give their employees an interest in increasing productivity.

The R.E.N.F.E. makes use of both systems, whilst the other Administrations only make use of the second method.

The additional payments depending upon an increase in productivity, which employees of the S.N.C.F. and S.N.C.B. enjoy, represent part of the savings obtained.

On the S.N.C.B., however, employees enjoying the supplements in question are those attached to the central shops where the staff is collectively interested in increasing productivity.

The interest of the staff of the F.S. and Jugoslavian Rys is based on the financial results.

2. *Proportion of the profit due to increased productivity which is returned to the staff in the two hypotheses in question.*

The information received only covered the second method.

Compared with the saving realised, the proportion is as follows :

S.N.C.F : 50 %;

S.N.C.B. : 50 % of the additional savings obtained when the output coefficient exceeds 1.25.

No other information on this point was supplied by any other Administrations.

3. *Organisations dealing with suggestions made by the staff.*

Rewards paid for such suggestions.

Two railways have a special department to deal with suggestions. These are :

— the S.N.C.F. with its General Studies Department;

— the F.S. with special organisations at the level respectively :

1) of the Traction installations;

2) the other sections.

On the S.N.C.F., suggestions are studied in the first place in the District concerned by an employee — qualified grade; then they are examined by the Region concerned by the competent technical department.

Suggestions which appear to be of general interest are then sent to the General Studies Management.

If the suggestion is rejected, a letter is sent to the employee concerned by the head of the department explaining the reasons why it was not acted upon.

Suggestions that are retained result in a letter of congratulation being sent to the employee in question and a reward being granted him.

On the F.S., the suggestions department of the Traction Department examines suggestions from the staff and sends forward to central headquarters those it considers of interest.

In the other departments, suggestions are sent directly to the Staff and General Affairs Department which sees that they are considered by the competent department.

In order to achieve greater uniformity and objectivity, it is proposed to entrust the examination of suggestions received to a collegiate organisation.

On other Administrations, where there is no special department for this purpose, suggestions are examined in the final resort by the department which they concern.

The preliminary proceedings differ slightly from railway to railway.

On the Danish Rys, the General Management submits the suggestion for consideration by the department concerned. It is then put before the Central Arbitration Committee which considers the reply to be sent to the author of the suggestion and what reward he should be given.

On the R.E.N.F.E., S.N.C.B. and C.F.F., suggestions are sent forward through the different grades in the usual way, but on the C.F.F. they are also put before the Staff Committees.

Suggestions put forward by employees on the Jugoslavian Rys are sent to the labour management office concerned.

Certain Administrations have a « suggestion box » and organise competitions.

In this connection, the S.N.C.F. holds a regional competition each year, and also a general competition for the best suggestions. The prize winners are entertained either by the regional manager or the General Manager. They also receive rewards.

Estimating the value of the suggestions put forward is not usually subject to any strict rules.

The savings to be expected from carrying them out is not the only criterion on which their value is estimated. The Administrations also take into account :

— the grade and duties of the employee making the suggestion;
— the knowledge and research he has shown;
— the amount of his own time that he has devoted to the project;
— the degree of initiative shown.

The rewards granted by the Danish Rys are most often 100, or 200 crowns, and in exceptional cases 300 crowns.

The Emmental Rys and S.N.C.B. grant rewards based on the average, at 1 % and at 2.5 % respectively of the saving obtained through the suggestion in question.

* * *

II. — Perspectives for studying work methods and output premiums.

1. *Work study.*

a) and *b*) Most of the railways have introduced work study. Some of them did so even before the last war, but in most cases work study does not go back more than 15 years.

c) Work study in entrusted either to departments whose sole responsibility this is, or to departments with other similar duties (work in connection with the organisation, rationalisation, drawing up tariffs and time tables, etc.).

Such departments hold widely different positions on the railways.

The S.N.C.F. for example includes :

— in each technical department, a department responsible for work study;

— in certain large shops or depots, a central time and motion office (B.C.T.T.);

— in the smaller shops and depots, work organisation offices.

It is difficult to estimate the number of employees engaged on work study.

Those engaged on work study are either young employees trained in scientific organisation of work methods, or responsible workmen or foremen familiar with these methods and an extensive knowledge of the actual work.

On the Danish Rys, an organising service attached to the Staff and Organisation Department is responsible for work study.

In the shops, work studies are carried out by a special work group consisting of 11 persons who have been trained for this purpose and who are mainly workmen with one or two engineers.

On the C.F.F., the department specially responsible for work study is attached to the General Secretariat and receives its instructions from the General Management or directly from the Department concerned.

This service consists of 5 employees : 3 university graduates, a specialist in time and motion analysis, an a technician.

On the F.S., there is an office attached to the Traction Department which, in addition to being responsible for the organisation, also deals with work study. It is the same in the case of the maintenance of the permanent way, the superstructure and the station working.

The employees who work in these offices are carefully chosen amongst those men who have shown special technical skill and special aptitude in studying organisation problems; they are trained for their new studies by experts in this field.

On the S.N.C.B., work study at the managerial level is part of the duties of the various organisation offices.

Each department has an organisation office, the work of these different offices being co-ordinated by the organisation office of the General Management.

The organisation offices employ organisation consultants holding a diploma from a school specialising in this subject.

In the organisation offices of the technical departments there are also engineers, employees from the traffic grades in the case of the Operating Department, and a few accountants in the Financial Department.

The strength of these organisation offices amounts to some 50 employees.

In the case of the large shops, there is also an organisation office responsible for the general studies in connection with the activities of the shop. The offices are run by technical officials, some of them engineers, assisted by technicians and executives of various grades. Most of the technicians and executives have received special training for this purpose.

d) Work study does not appear to be treated as of equal importance on the different railways.

It can however be said that work study is most often undertaken in the shops.

This is the case in particular on the R.E.N.F.E., S.N.C.F., F.S. and S.N.C.B.

The reason for this must be looked for in the fact that in the shops the various jobs are more individualistic and less complex, the equipment more rationalised, and the work less likely to be affected by atmospheric and traffic conditions than elsewhere on the railway.

The C.F.F. have used work study above all in connection with their Operating and Works Departments, as well as the office work of various departments.

In any case, it is generally admitted that it is in the field of operating, and particularly as regards the stations, that work study has given the best results.

2. *Work study methods.*

The diversity of the jobs in question makes it impossible to standardise the methods of work. These vary from railway to railway, and even from department to department on one and the same railway.

— *On the S.N.C.F.*

In the shops and depot, the method usually used is that of the basic times and time and motion (the method of the basic times by the use of time lists is normally applicable and time and motion studies are only made when the information already available is insufficient).

In the case of time and motion studies, the sample labour on which these are based is taken by choosing employees of average capability.

In the stations, first of all an analysis of the work is made, taking into account the traffic statistics, the traffic diagrams, the arrangement of the installations and material means available; then the conditions under which the work must be carried out, and the number of employees required are determined and motion graphs drawn up for the staff in order to make the best possible use of their labour.

Permanent way work (maintenance and renewal) is analysed by breaking it down into its various component jobs according to the nature of the operations. The time required for each operation is then calculated (removal of ballast, shovel packing, tightening up the fastenings), according to the number of men employed.

Organised gangs are then set up in which the men are specialists in carrying out well defined jobs, losses are carefully eliminated, and the methods used mechanised.

— *On the C.F.F.*

Use is made of motion diagrams for all the operations and observations are made on site.

— *On the Emmental Rys.*

Traffic diagrams are used.

— *On the F.S.*

The study methods used are generally derived from time analysis studies.

— *On the S.N.C.B.*

The S.N.C.B. proceeds in the same fashion as the S.N.C.F. as regards work in the shops and on the permanent way. The methods of basic times are currently applied.

In the stations, work study is partly based on organisation charts, traffic diagrams and track occupation diagrams.

Office work is also the subject of a careful analysis.

3. *Work processes.*

The railways only concern themselves with time study.

4. *Synthetic tables.*

a) Most of the railways draw up tables of synthetic data for the main operations.

The following explanations were given in this connection.

S.N.C.F.

For certain jobs, tables of synthetic data are drawn up for the main operations. These tables are drawn up after studying the work, logically analysing and defining the elementary jobs, measuring the operations and preparing statistical curves of the results.

The synthesis graphs show the job to be done by each man, the time allowed

for each job, and for the work as a whole, and the tools to be used.

Benguela Rys.

The work is shown on graphs where the beginning and end of each of the main phases are laid down.

C.F.F.

Synthetic tables are used of the type suggested by the R.E.F.A. (Germany) or General Productivity Commission (France).

F.S.

Work on the rolling stock is always the subject of synthetic tables which cover in their chronological order all the operations which are either repeated regularly or intermittently.

S.N.C.B.

Most of the jobs done in the shops are the subject of repair orders and manufacturing notices which specify the operations to be carried out, the time allocated for them, the materials, tools and machines to be used.

Other jobs, especially certain office work, are the subject of orders describing the rational way of carrying such work out.

b) *Method of basic predetermined times.*

In practice, this is hardly ever used.

5. *Judging the rate of working.*

a) *Method of judging.*

The railways practice but little judging the rate of working.

The R.E.N.F.E. have made a limited use of this method, as have the S.N.C.F., who admit that the stop watch timings are 10 % higher than the values of the times of the details taken from the tables.

The C.F.F. use the R.E.F.A. (Germany) system.

On the F.S., the rate of work is judged on the ratio between the basic established times and time taken in practice.

The S.N.C.B. make sporadic use of the basic times system.

b) *Scale of evaluation.*

The R.E.N.F.E., like the C.F.F., use the scale 75/100 which, moreover, is that used by private enterprise when reorganising some of the repair shops on their system.

The S.N.C.B. shops use the scale 100, which corresponds to normal work without undue fatigue.

6. *Time allocation.*

In allocating the time, account is taken :

— of all unproductive time (R.E.N.F.E., F.S.);

— of a period for relaxing, which varies according to the work, and represents 8 to 15 % of the allotted time (Benguela Rys); on the average 5 % (C.F.F.); 15 % of the normal working time of the shop, and more in the case of work on the forge or foundry (S.N.C.B.);

— a coefficient to take into account fatigue and inevitable stoppages.

This coefficient is added to the strict time needed for the elementary movements and operations involved in doing the job. It varies according to the category of work and conditions under which it is carried out.

7. *Organisation responsible for work study in the offices.*

The following Administrations have such an organisation :

Danish Rys; R.E.N.F.E. (in the case of the mechanised statistic office); S.N.C.F. (Organisations and methods section); S.N.C.B. (an organisation ofice for each department, at central administrative level).

The F.S. are setting up a similar organisation at the present time.

8. *Organisation. Position of the study or organising department as regards the organisation dealing specifically with productivity.*

As stated under heading I. A. 2. *General*, the majority of Administrations have no organisation dealing exclusively with productivity.

Problems in connection with productivity are dealt with in the study or organisation offices.

9. *Training.*

a) Apart from the S.N.C.F. which, in principle, itself trains its work study specialists, either in the regional centres or in a single centre in the case of monitors, no other Administration has its own training centre for specialists in work study.

On the S.N.C.F., a certain number of employees intended to be formed into a unit are, however, sent each year to the School of Scientific Work Organisation which is a private state-recognised school.

On the S.N.C.B. only the time study staff is trained by the Company.

The organisation advisers are selected amongst the staff for their innate talent for organisation, and most of them have attended courses at a special school and obtained their diploma.

b) The figures quoted as regards the number of employees who have received a basic training in work study technique and who are used in the corresponding functions, are as follows :

— Danish Rys : 100 men out of a total of 27 000, or 0.4 %;
— S.N.C.F. : 0.15 % to 0.2 % of all the staff;
— Benguela Rys : 3 men (2 engineers and 1 inspector) ;
— C.F.F. : 60 men, or 0.0015 % of all the staff.

c) In reply to the query as to whether the Administrations should increase the number of employees mentioned in the previous paragraph, the answers were :

— the S.N.C.F. considers this number is sufficient;
— the Danish Rys expect to train about 10 employees a year;
— the C.F.F. consider they should increase to 100, i.e. 0.0025 % of the whole of the staff the number of employees trained for work study.

d) The S.N.C.F. has organised certain weeks of instruction and those who attend these are afterwards incorporated in work groups in which their training continues.

10. a) and b) *Organisation consultants.*

The railways make very little use of external sources of expert advice for dealing with work study questions.

Exceptions are mentioned by :

— the R.E.N.F.E., who called upon an outside specialist to reorganise certain repair shops;
— the S.N.C.F. for the organisation of the administrative services;
— the Benguela Rys, who obtained the collaboration of a British Railways official when adapting their central shops for certain work methods used by the British Railways;
— the C.F.F. to examine certain special cases;
— the F.S., who consulted experts in order to improve certain administrative procedures;
— the S.N.C.B., who had studies carried out regarding :
  — the qualification of the work;
  — the development of productivity in the central shops through the introduction of a collective bonus system;
  — the improvement of the organisation of the work of inspection, accountancy and consigning of parcels from a large station.

Output bonus.

The output bonus can be granted :

— directly to each employee as a function of his individual output;
— to a gang as a function of the collective output of the gang, after which

it is distributed amongst the various member, in equal parts, or on the basis of various factors such as : rank, wage, number of hours of work, combination of the above factors, factors proper to each individual (for example : seniority, personal merit, professional merit, individual output).

11. a) and b) *Bonus systems.*

The following table sums up the information supplied in this connection.

Administrations	*Application of output bonus*		*Category of staff enjoying bonuses*	*Special information*
	individual (1)	*collective* (2)		
Danish Rys.				In shops where there is piece work.
R.E.N.F.E.	x	x	(1) Employees working : — in the shops; — mechanised offices; — administrative.	(1) Whenever possible. (2) More rarely because less effective and stimulating in this case.
S.N.C.F.	x	x		(1) 42 % of all the staff; (2) 58 % of all the staff.
Benguala Rys.				The introduction of output bonuses is contemplated.
C.F.F.	x			A trial in view of its general introduction is projected in a mecanographical service.
Emmental Rys.	—	—	—	—
Jugoslavian Rys.	x	x	(1) Rolling stock maintenance department. (2) Operating department.	—
F.S.	—	x	(2) Employees engaged on repairs to rolling stock and permanent way.	Bonuses established per : — gang, 3 to 6 men in the case of work which can be evaluated analytically. — per gang and per installation for work in the general departments where it is not possible to prepare analytical rates on a time basis.
S.N.C.B.	x	x	(1) Nearly all the men except those mentioned under (2) below. (2) Employees in certain central shops.	

None of the railways has generalised the use of one or other of these systems.

12. *Formulae and methods of calculating output bonus.*

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Method of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
F.S.	$P = Pb \cdot t \cdot E$ in which Pb = hourly bonus based on type of work and degree of specialisation. t = time effectively employed during the month on carrying out the work. $E = \frac{T - t}{t}$ in which T represents the monthly time allowed by the working schedule. The same formula is applied when it is a question of a bonus for a gang or establishment in the case of staff contributing indirectly to the production. In this case, the saving E is that realised by the whole of the gang or the establishment.	—	— The amount due to each individual is determined according to a coefficient of individual evaluation having an average value of 1.	monthly
R.E.N.F.E.	Similar to above system on the F.S.	In some repair and maintenance shops for the traction stock the bonus is a function of the relation : $\frac{\text{locomotives - km}}{\text{total number of men}}$		
S.N.C.B.	Individual bonus the formula for which varies as a function of work which has no direct relation with output.	*Individual bonus for good work.* Each job the carrying out of which ranks for bonus is assigned an hourly or daily rate. Each man concerned, has his work evaluated by this foreman. The amount of the total bonus is obtained by multiplying the basic rate by the effective monthly output and applying the agreed scale to the product.		

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Methods of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.B. (continued).	—	*Collective bonus* for employees at the central shops where the staff is interested in increasing productivity. The bonus is calculated per gang. It is a function of the output of the gang to which the bonus scale in force in the Rolling Stock Dept. is applied no matter what the output. *Bonus for travelling traction dept. staff.* These are established as a function of savings in fuel consumption, regularity of running of the trains, the way the engine is kept, and vigilance.	The total bonus earned by the gang is divided up amongst all its members as a function of the time each has worked and the hourly rate for the job in question in the gang, multiplied by a first coefficient based on individual output and a second coefficient for the working point in question.	monthly
Benguela Rys.	—	—	—	—
C.F.F.	No definite formula.	—	—	—
Emmental Rys.	—	—	—	—
Jugoslavian Rys.	No systematic formula.	—	—	—

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Methods of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.F.	—	*Bonus (traction bonus) for locomotive drivers on train working and shunting duties.* According to the nature and the service, they are calculated proportionally to the time on duty, mileage worked, time made up in case of delays, and savings in traction power. They are given coefficients which differ according to the types of trains and the difficulty of the services.	—	All bonuses are monthly.
	Work on non-standardised basic time rates.	The product of the average hourly bonus for each grade by the total number of working hours by the men in the grade on work giving right to bonus is divided between those affected.	Pro rate for time worked and bonus earned by each of them measured by the formula : $\frac{T - t}{T}$	
	Rolling stock and Traction Department : production bonus calculated from a basic hourly rate as a function of individual or collective output. Work on standard time rates. $P = pt \frac{T - t}{T}$ P = rate fixed for each grade; T = time allotted for job in question; t = real time.		In the case of men working in gangs, the bonus : $\frac{T - t}{T}$ is collective (total of times allotted and worked by the gang). Individual bonus is a function of the number of hours the employee works in the gang.	

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Method of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.F. (continued).	*Bonus for fuel depots.* $P = pt \frac{q - Q}{Q}$; P = bonus earned by employee; p = hourly wage fixed for each grade; t = time the employee takes to do the job; q = hourly tonnage handled by the gang; Q = basic hourly tonnage. Bonus : $\frac{q - Q}{q}$ is a collective one calculated per gang. *Bonus for staff inspecting trains in the stations.* $P = tj\,(A + B)$; P = bonus due for the month; t = number of days per month entitling to bonus; j = basic daily rate varying according to grade; A = characteristic of the difficulty of the service in question and common to all men on the same post; B = characteristic of the quality of work of each man. This formula is also used to calculate *the monthly bonuses for the foremen of the Rolling Stock and Traction Dept.*, but in this case A represents the difficulty of the job and quality of management of each establishment; B represents the quality of the services of each employee.			

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Methods of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.F. (continued).	—	*Operating Dept. bonuses.* Granted to : 1. Executive and managerial staff whose output can be directly measured : — ordinary shunting bonus; — speeded up marshalling bonus; — handling bonus; — goods office bonus; — receipts bonus. 2. Staff whose output is not measurable : — station staff productivity bonus; — productivity bonus for district managers; — productivity bonus for train staff; — bonus for operating dept. workmen. *Principle :* to distribute a fraction of the savings due to an improvement in output and the quality of the work compared with what is considered normal. *Permanent way and buildings dept. bonuses.* *Production bonus for platelayers and gangers.* This is a function of the savings made on the numbers of employees maintaining the permanent way and on the sums spent on maintenance work normally carried out by contract. It is collective.		

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Method of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.F. (continued).	—	*Bonuses for men in the Electricity and Signalling Dept. and technical gangs.* *(Maintenance of the electrical installations on the line the signalling, the catenaries, the buildings, the points installations).* The average amount of this bonus equals, according to rate of pay of the men, either that of the Rolling Stock and Traction Dept. men working in the stations, or that of the platelayers. The value of the bonus compared with the average value is obtained by means of a characteristic rating which takes into account the difficulty of the work, the quality of the work done, and the results obtained. *Bonus for Shops and Stores of the Permanent Way Dept.* *Production bonuses for executives.* The average value of this bonus equals that paid to employees in the Rolling Stock and Traction shops working on non-stadard time rates. The average value of the bonus compared with the average is based pro rata on the premiums earned by each workman and determined by relating the time worked with the time allotted for the job. *Bonus for managerial staff.* This has an average value equal to that of the managerial bonuses for employees in the Rolling Stock and Traction Dept. shops, and it is distributed amongst those concerned according to an agreed rating.		

Administrations	*Formulae used*	*Methods of calculating the bonus*	*Methods of dividing it up between individuals if it is collective*	*Periodicity of the bonus*
S.N.C.F. (continued).	—	*Collective bonus for sleeper finishing shops.* The daily rate is a function on the one hand of the total number of working hours during the month for all the shop employees and the staff of the undertaking and on the other hand the monthly production of the shop. *Personal bonuses for the staff of the administrative departments.* These have a collective character and their average daily basic value is fixed by the General Manager. This value cannot be exceeded. The bonus must however vary in order to take into account the quality of the work done and the results obtained in each of the homogeneous working groups that have been specially set up. The use of a characteristic notation makes this possible. *Production bonuses for the mecanographical shops.* The bonus is determined by taking into account : — fictitious units representing the operations carried out; — scales established for each type of work showing the hourly bonus corresponding to the output achieved.		

13. *a*) and *b*).

The following table shows the only numerical data we received. Amongst these, none refer to increased productivity.

Any idea of establishing any correlation between the two kinds of information had therefore to be given up.

Administrations	*Average value of bonus as an absolute value*		*Percentage of bonus compared with average overall wage*		*Percentage of increase in productivity*	
	1957	*1958*	*1957*	*1958*	*1957*	*1958*
Danish Rys.	—	—	—	—	—	—
R.E.N.F.E.	—	—	—	—	—	—
S.N.C.F.	—	—	—	—	—	—
Benguela Rys.	—	—	—	—	—	—
C.F.F.	350 F	350 F	5 %	5 %	—	—
Emmental Rys.	—	—	—	—	—	—
Jugoslavian Rys.	—	—	—	—	—	—
F.S.:						
Skilled workers	157 000 L	195 000 L	23 %	25 %	—	—
Qualified workers	134 000 L	170 000 L	23 %	25 %	—	—
Labourers	112 000 L	145 000 L	22 %	24 %	—	—
S.N.C.B.:						
Employees having individual bonuses	1 800 F	1 800 F	2 %	2 %	—	—
Members of gangs (collective bonus) in one of the shops where the staff has an interest in productivity	9 000 F	9 000 F	9 %	9 %	—	—

14. *Output bonus.*

Administrations	a) *Number of employees earning a bonus*	b) *Percentage of employees earning a bonus compared with total labour force*
Danish Rys.	—	—
R.E.N.F.E.	—	—
S.N.C.F.	—	—
Benguela Rys.	—	—
C.F.F.	—	—
Emmental Rys.	—	—
Jugoslavian Rys.	—	—
F.S.	31 000	20 %
S.N.C.B.	57 600	80 %

15. a), b), c) *Output bonuses calculated as a function of a standard minute values.*

This system is not used.

16. *Various.*

The few cases of work study, which according to the information received from the Administrations, were the best they could find during the years 1957 and 1958 do not allow any satisfactory report to be prepared on the question.

17. The questionnaire was considered adequate by the various Administrations.

CONCLUSIONS.

I. — Co-operation between the management and the staff in order to improve productivity.

The great majority of the railway Administrations consider and measure productivity either at the all lines or headquarters level or at the level of its main subdivisions.

Very few indices are available concerning productivity at the lower levels.

It is a moot point whether the formulae, which express productivity in this generally classic way, are able to stimulate co-operation between the management and the staff, so essential if any progress is to be made in increasing productivity.

One formula, that of the S.N.C.F., appears to merit study because, on the one hand, it translates any increase in productivity immediately into a bonus payment, and on the other hand, it could be applied at all levels.

The other formulae, which are all very like each other, are merely so many statistics as far as the staff is concerned, and thus fall short of the objective with which we are concerned.

In addition, it should be pointed out that even the indices expressing productivity at the lower levels are still too far short of the mark.

From these considerations, it appears that apart from general productivity indices, it is clearly necessary to consider expressing the productivity achieved at the lowest possible level.

Formulae, which can easily be understood by the staff, must include all the various factors which affect productivity.

These remarks also apply to the administrative work which would appear to be excluded from the productivity formulae.

Such a state of affairs would seem to be paradoxical when one considers the vast amount of administrative duties which running a railway entails.

There is no doubt that the reason for this must be that on account of its very nature, administrative work does not lend itself to any rigorous evaluations.

It is indisputable, however, that an increase in productivity in this field is not only possible but can often be achieved without formally appearing.

It is desirable that if it be that the collaboration of the administrative staff is wished for just as much as that of other employees, he should be able to follow the evolution of his productivity and have an interest in the benefits expected from any increase therein.

* * *

Although a central organisation dealing especially with questions of productivity would appear to be a functional necessity, there has been no report of the existence of any such organisation.

The Administrations are however giving their closest attention to the problems of productivity which they entrust to departments whose duties are closely linked up with these problems. In this way, they achieve the objectives aimed at.

It is a question whether these objectives could not be widened by the creation of

a central organisation of this sort, though it would have to have many ramifications.

These would lead to the setting up of base cells or committees.

On the other hand, a central organisation would be able to co-ordinate through the national offices for the increase of productivity, the relations between them and the various departments of the Administrations.

The next step would be the possibility of setting up an international railway productivity office.

* * *

It is unanimously agreed that of all the factors contributing to increased productivity, the human factor is the most important.

It is therefore quite rational that in the field of productivity, the human problem is the first one to be considered.

This point of view is moreover very clearly brought out in the work of the 2nd National Productivity Congress, which was recently held in Brussels.

In his opening speech, the President stressed the point that « productivity is above all an atmosphere. Keeping the workers informed on the methods to be used and about the results obtained is a fundamental factor in creating such an atmosphere. Certain measures that are taken may have momentarily disagreeable consequences for the workers, but it should be possible to warn them against these dangers and in all cases make sure that they are never its victims ».

A similar need has moreover been experienced by the railway Administrations, which have all endeavoured to create an atmosphere of confidence.

Naturally, there are various ways of attaining such an end. It is not possible to determine which of them is the best, but each railway apears to have adopted the method best suited to their own national psychology and contingencies.

One point is commonly agreed : in all cases the staff organisations have been called upon to collaborate.

In this connection, stress should be laid on the Joint Declaration, signed on the 5th May 1954, in connection with productivity by the most representative employers' and workers' organisations.

This Declaration is still in Belgium the fundamental charter on which are based all efforts to increase productivity.

The Administrations have very clearly understood the problems which the consequences of increased productivity raise as far as the staff in concerned, and these are referred to in the second part of the above mentioned Joint Declaration.

It should be pointed out that the railwaymen's statutory rights already give them considerable guarantees as regards stable employment.

The Administrations respect this statutory stability and consequently spread out in time and space the effects of increased productivity.

In practice, the only danger — if there is any danger — with which the railwayman is faced, is a transfer, or the need to submit to a different employment.

Here again, it should be pointed out that in such cases the Administrations concerned do act with great circumspection and correctness.

In the same way, the Administrations are doing all in their power to put their workmen in the best possible conditions to accomplish and sustain the supplementary efforts inherent in any increased productivity.

The above considerations do not however exhaust the subject.

It is indisputable, and moreover only equitable that the benefits of productivity should be shared between the undertaking and the workers.

It would appear that such a sharing of the benefits has not yet become a reality.

It must not be forgotten, however, that

the majority of the Administrations pay an output bonus according to the traditional formulae, which they have a tendency to associate with the notion of an interest in productivity.

It would appear however that there is a tendency towards a better understanding of what interesting the staff in productivity really means.

II. — Work study. Efficiency bonuses.

At the present time, all the railways to some extent are carrying out work study which is entrusted to specialised offices. The similarity, which one might expect to find in the organisation of such services, does not exist in practice.

Various factors may explain this diversity, in particular the extent of the work study, the methods and processes used, the statutes, the structure and the extent of the railway systems.

However, at the present stage, most of the railways consider that their work study department meets their requirements.

It is consequently difficult to express an opinion regarding the future perspectives of work study on the railway.

It is however possible to forecast that work study will be called upon to undergo an extension, seeing that its application to any degree is relatively recent.

Systems of efficiency bonuses varying considerably from railway to railway, but all inspired by the classic principles, are in force on a good many railways.

What would appear to be the perspectives for their future evolution?

Will they be developed or will they gradually be given up?

It is difficult to express any certain opinion on this subject.

In any case, it would appear likely that should efficiency bonuses in their present form be extended or even stabilised, it would be advisable to consider uniformity of the different systems in view of the uniformity of railway activities.

It might be added that this measure would be the first step towards harmonising of revenues, so very desirable in achieving the common European aims.

Apart from such considerations, account must also be taken of the tendency there is nearly everywhere to interest the staff directly in the benefits of increased productivity by the use of collective formulae, which would appear likely gradually to lead the Railways away from the idea of efficiency bonuses.

[385 .58]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(BRUSSELS, 1960).

QUESTION 4.

What steps can be taken to develop and maintain co-operation between management and staff to improve productivity?

What scope is there for work study and incentive schemes?

REPORT

(America (North and South), Australia, Burma, Ceylon, Egypt, West Germany, Ghana, India, Irak, Iran, Republic of Ireland, Japan, Malaysia, Netherlands, New Zealand, Norway, Phillipines, South Africa, Sudan, Sweden, Union of Socialists Soviet Republics, United Kingdom of Great Britain & Norhern Ireland and dependent overseas territories and Uruguay),

by Edgar J. Larkin, A.M.I.Mech.E., M.I.Loco.E.

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1. INTRODUCTION.

a) Acknowledgment.

Twenty-eight administrations replied to the questionnaire in English. Nine of these stated that they found the questions inapplicable or had made such limited efforts in the directions indicated that they had nothing useful to contribute. The remainder supplied a very large quantity of interesting and helpful information. This, together with material drawn from other sources, has formed the basis of this report. Your reporter wishes to place on record his gratitude, both to those administrations who replied to the questionnaire and to those not belonging to the Association who have given him so much assistance, for their co-operation. He also wishes to place on record his sincere thanks for the considerable contribution made by his assistant Mr. J. C. F. Cameron, A.M.I.C.E.

b) Outline of the Report.

This report deals with the question under eight main headings and twenty-six subheadings accompanied by six appendices, as set out below.

1. **Introduction.**
   - a) Acknowledgment;
   - b) Outline of Report;
   - c) Range of Replies;
   - d) Productivity and Work Study.
2. **Productivity Measurement.**
   - a) The Development of Productivity Measurement;

b) The Meaning of Productivity Measurement;
c) The Practice of Productivity Measurement.

3. **Organisation for Work Study and Productivity.**
   a) Work Study and Productivity Organisations;
   b) Railway Productivity Councils;
   c) Relations with National Productivity Councils;
   d) Use of Industrial Consultants.

4. **Human Relations for Increased Productivity.**
   a) Railways and Human Relations;
   b) More Traffic or Less Staff?
   c) Maintaining Collaboration for Increased Productivity;
   d) Suggestions Schemes.

5. **Work Study.**
   a) Definitions and Developments;
   b) Method Study;
   c) Work Measurement;
   d) Activity Sampling.

6. **Work Study Training.**
   a) Training Centres and Courses;
   b) Qualifications of Personnel;
   c) Progress.

7. **Incentives.**
   a) Non-Financial Incentives;
   b) Financial Incentives Based on Work Study;
   c) Other Financial Incentives;
   d) The Principles of Financial Incentives.

8. **Conclusions.**

Appendices.

I. A detailed illustration of the Productivity of Labour;
II. Organisations for Work Study and Raising Productivity;
III. Table of Work Study Practices in Railway Administrations;
IV. An example of a Process Chart;
V. Examples of a Flow Diagram;
VI. Case Studies of the Application of the Scientific Organisation of Work in Railway Administrations.

Bibliography.

c) Range of Replies.

The questions and, consequently, the questionnaire, pre-supposed some conflicting interests as between management and staff. This conflict is clearly very real in some administrations, whilst in others the common interest and understanding are stronger so that, in theory at least, many of the problems which occur in one do not exist in another. The replies range from that of the U.S.S.R. railways, which makes the point that on the basis of their socialist principles the relationship between the railway management and the staff presents no special problems, to that of another administration which holds the view that other factors are of equal importance in increasing productivity.

The practice of Work Study, which is specifically mentioned in the second part of the question, was closely defined in the questionnaire, and the use of the techniques known as *method study* and *work measurement* was implied. Several administrations understood these and some have supplied informative examples of their application to railway work. Other administrations state that they do not use Work Study, whilst several describe practices which are only vaguely related to the modern conception of the techniques defined.

d) Productivity and Work Study.

In view of the evident misunderstanding of the term Work Study and of the accepted practices which it involves, a few notes follow which outline the technique and explain why your reporter has referred to Work Study throughout.

In the questionnaire, and in Part 5 of this report where these notes are expanded, Work Study is defined as the critical examination of any work with a view to making the most economical and effective use of men, materials, equipment and buildings. Current practice is for this examination to be most thorough involving analysis of work into units measured in

standard minutes. Individual movements are recorded very methodically and accurate assessments of the speed of working and the effort involved are recorded. No technique of science is ignored in the application of Work Study when the precise details of any activity, or the scope for its improvement, has to be determined.

Work Study involves the study of the manner in which a job is performed and the time that it takes. It falls under two main headings : *method study,* by means of a number of established graphical and statistical techniques, enables all the details of a job to be recorded and studied; and *work measurement,* by means of close time study and effort rating, enables an extremely accurate calculation to be made of the times for tasks. Readers are referred to the excellent publication of the International Labour Office entitled « Introduction to Work Study » which illustrates the direct connection between Work Study and Productivity, for the study of work is essentially the study of productivity.

The International Railway Congress Association has been concerned with productivity under other terms in earlier reports and proceedings. The most notable were the reports in 1930 and 1933. In 1930 three reports were made on the subject of the co-operation of the staff towards increased efficiency and the participation of the staff in the profits. The first was a comprehensive paper by Messrs. Soulez and Bloch, and the second, a shorter report by C. C. Cook, an outline of practices in regard to piecework and other incentive schemes and related matters. In the third report by Messrs. Marin del Campo and J. Canovas del Castillo, great stress was laid upon the advantages of scientific management instead of the merits of incentive schemes. The authors referred to Ambrozivics who had advocated the scientific approach in his report on a similar question to the Congress in 1889. They also referred to the well known « Taylor System » and to the conclusive evidence of the work of Henry Ford on the Detroit, Toledo and Ironton Railroad in the early 1920's. In their conclusions, which were adopted by the Congress, the authors of the third report recommended that the whole subject be tackled afresh so as to incorporate the question of scientific management.

The reports of 1933, therefore, dealt with « Instances of the application in a railway department of the scientific organisation of work », as well as « Co-operation of the staff towards increasing efficiency and their participation in the profits ». Three reports were again presented, that from Messrs. Soulez and Bloch being an extensive document which dealt with several examples of elementary Work Study and related techniques. With a full bibliography and a film display these authors certainly fulfilled the wishes of the previous Congress. It would, indeed, seem that the Congress has not returned to the topic for nearly thirty years.

During this time the « scientific organisation of work » has developed enormously and is at present developing at an increasing rate in much the same way as one sees technical development in other spheres. The word efficiency has given way to the more precise term « Productivity », which is defined as the ratio between input and output. The measurement of Productivity has become the subject of serious study in its own right, and the technique of Work Study under a number of different terms has been widely accepted.

At the same time the relationship between employers and employees has shown a marked change which has called for more enlightened thinking by management which must now have greater regard for the feelings of its staff. Indeed, the two extremes of employees in an administration have grown much closer together finding common interests and common responsibilities.

2. PRODUCTIVITY MEASUREMENT.

a) The Development of Productivity Measurement.

The basic concepts of Productivity and Productivity Measurement are elementary. Unconsciously, the one has been understood and the other practised ever since organised human work began. Recently, within the last fifteen years, closer thought has been given to Productivity and to the measurement of productivity, and extensive studies of Productivity Measurement have been made. Books have been published by the European Productivity Agency and by the « Société Auxiliaire pour la Diffusion des Etudes de Productivité » and by others who have attempted to trace a simple history of the subject. In the paragraphs which follow, this history is outlined and concluded with an indication of the activities of the International Union of Railways with regard to the matter.

Apart from the use of the word « Productivity » by Agricola in 1530, the first precise interpretation was put on it by the French physician François Quesnay in 1766 when he developed the concept of the analysis of productive activity. The Input-Output Theory, which is based on the same concept, was examined by Walras towards the end of the nineteenth century. More recently, Professor W. W. Leontief of Harvard University, has applied the theory to the entire economy of the United States. In 1948 Dr. Laszlo Rostas completed his major work « Comparative Productivity in British and American Industry ». This revealed the differences between the two countries and supported his conclusions with massive statistical evidence showing that there was no single factor to account for the differences. From this beginning appeared the European Productivity drive and the creation of the European Productivity Agency and National Productivity Centres. The Bureau of Labour Statistics in America collected man-hour statistics and studies were made in France by the « Centre d'Etudes et des Mesures de Productivité ».

From all these studies it was found that often where the man-hour requirement for a total operation differed in two firms or countries, some broad difference in circumstances which might have been thought to be the reason was not discovered in the analysis. When the operation was broken down to the level of identical specification, the overall differences were found to be in the requirements for individual elements. It is clear that these conclusions hold much interest for those concerned with scientific management of work in general, and of Work Study in particular.

On railways all over the world, as will be shown, forms of productivity measurement have been practised in the compilation of certain statistics for many years but not with the conscious intention of revealing the measure of productivity. The International Union of Railways has approached the question through the activities of two of its Committees. The Third Committee, which deals with Finance, Accounts and Statistics, has instituted investigations into the productivity, that is, the utilisation of Goods, Stock and Passenger Stock, and into the productivity of staff on stations, on permanent way maintenance and on motive power duties. The Sixth Committee, which is the General Committee, has established working parties to investigate productivity on railways generally and measures to interest the staff in productivity.

The investigations of the Third Committee into utilization of rolling stock were reported at its meeting in Budapest in 1958. Indications of its lines of approach and of its recommendations are given subsequently in this report. Unfortunately, this Committee's studies of labour productivity have made little progress. The work of the Sixth Committee, regarding the productivity of railways

generally, culminated in a report, not translated into English, published in 1957. This also is discussed later in this report. The Sixth Committee's studies of measures to interest staff in productivity have made little tangible progress.

b) The Meaning of Productivity Measurement.

As mentioned in the introduction to this report, the definition of Productivity, which is now generally accepted, is :

Productivity = ratio between input and output. Broadly, the input must be measured in all factors, land, equipment, materials and labour. Where the productivity of any single one of these is intended, the more accurate terminology becomes land productivity, equipment productivity, and so on. It has, however, become so customary for thoughts to turn to the productivity of labour that unless specifically stated otherwise, the term « Productivity » is often taken to mean productivity of labour alone, especially where the labour content, as in railways, forms a relatively high proportion of the overall running costs.

On the face of it this would seem a somewhat careless and misleading assumption, although it can be proved that where there is an increase in the productivity of any one of a number of interdependent factors, the productivity of the others is also increased. In view of the fact that in the present pattern of human endeavour, the factor of labour appears in every major operation, either directly or indirectly, the measure of Labour Productivity is a clear indication of the productivity of all factors involved.

The concept of productivity is clearest in the cases of factory production where materials figure highly in the input and tangible goods are the principal output. In such cases, the concept of Productivity Measurement acquires a more intelligent meaning. On railways the factors are less obvious and their measurement much less straight-forward. The term « Productivity », in the sense that it applies to Productive Efficiency, has to be interpreted broadly with the intention that Production includes all useful work. Applying the basic definition of Productivity to railways one obtains the results set out in figure 1.

It will be obvious from figure 1 that measures of partial productivity have been made for many years. The statistics published by all railway administrations and, in particular, those issued by the International Union of Railways, contain figures of utilisation, such as passenger kilometres per carriage or per seat, and tonne kilometres per wagon. In the form of costs and receipts, indications of productivity are again illustrated. These thoughts point to two lines of approach to productivity measurement. First, to the analysis of overall measurement of the productivity of railways, as shown in figure 2, into figures of total utilisation of factors and to elementary utilization in time, locality or units, as illustrated in Appendix I. Second, to the question of the relationship between physical measurements of productivity and financial measurements, where use is made of coefficients to account for fluctuations of monetary values.

All the serious studies of productivity measurement have distinguished between overall measurements of input and output, and various degrees of detailed measurement, at depot level and at the level of the individual worker himself. At this last level, labour productivity is the same as the effective performance of the worker. This is measured by labour control schemes and, through incentive schemes, is practised widely. Many of these, moreover, lead to the calculation of performances of groups of staff and departments based on the aggregation of such figures. The productivity of other factors at this lower level is fairly represented by the statistics already referred to in respect of utilization of stock which themselves are but totals of local figures.

Input		*Output*
By definition	*On railways*	*On railways*
		Services
Land	Land Way Works	(i) Transport : functional and recreational (ii) Ancillary services :
Equipment	Signals Stock	(*a*) Storage (*b*) Guidance (*c*) Refreshment (*d*) Comforts and amenities
Materials	Fuel	(*N. B.* — Handling, shunting and other work which the customer receives is not a service because he would rather not have it if it could be avoided)
Labour	Staff	

Fig. 1.

The accumulation of unlike factors is the greatest problem of productivity measurement. In so far as labour is concerned, *work measurement,* by means of standard work units, is producing a common unit of output of work even though this activity, such as handling or shunting in the case of the railways, is not always the output of the industry. The measurement of net output, that is, of service, as distinct from the work that is done to provide it, is more difficult. So long as a single unit, such as passenger miles, is involved, the measure is simple enough, but as soon as ton miles has to be added, a system of weighting by coefficients has to be considered. When the more indirect elements of service, namely, storage, safety, amenities and comfort, have to be taken into account, the problems of aggregation become insuperable.

The simplest solution to this is surely the oldest one, namely, the evaluation of all factors in terms of a common unit — money. This has invariably been regarded as the logical approach and it must be puzzling to many when suggestions are made that any other form of measurement is useful, let alone necessary. This question was posed to the administrations of the International Railway Congress Association. Several replied by pointing out that prices and values change with the value of money, whereas physical units do not. The South African Railways regarded monetary factors as unsuitable for measuring physical performance.

Naturally, the value of money can be taken into account by the introduction of coefficients or factors based on cost indices, and many systems of productivity measurement which make use of monetary factors employ this means of relating all measurements to a common basis. Two other reasons for departing from pure monetary measurement were quoted in the replies to the questionnaire. One was the point that due to the complexity of a railway undertaking and the inter-dependence of its various sections and departments, any attempt to show the performance of any one part by normal accounting is fraught with complications. The other point, and one which from the productivity measurement and Work Study points of view is most important, is that figures of

financial profit or loss give no indication on their own of the scope for more profit. One hundred per cent utilisation of equipment and manpower provides no scope for improvement by change of schedules, whereas, say, forty per cent utilization, however profitable, always contains sixty per cent potential increase.

c) The Practice of Productivity Measurement.

Most of the administrations which replied to the questionnaire in English were regular contributors of statistics to the International Union of Railways. In addition, three of these had contributed to the investigations of the Sixth Committee which produced the general report in 1957. This illustrated by graphs and tables the productivity of railways under a number of headings, namely, overall, labour, motive power, material and rolling stock. Neither British Railways, nor the Japanese National Railways took part in this exercise, but if calculated on a similar basis the figures for the countries become :

Factor	*Year*	*Germany D.B.*	*Japan J.N.R.*	*Netherlands N.S.*	*Sweden S.J.*	*United Kingdom B.R.*
Overall . . .	1950	100	100	100	100	100
Labour . . .	1955	126	151	126	110	106
Productivity .	1956	131	163	131	111	107

Fig. 2.

Points which are emphasised are that these figures alone have little meaning and that direct comparisons can be misleading. Nevertheless, analysis to the level of the work itself may well reveal a state of affairs such as that revealed by the work of Rostas already mentioned. As discovered by the Third Committee of the International Union of Railways, the work of analysis and of the satisfactory calculation of coefficients for direct comparison can become most complex. This is illustrated by quoting only one of the formulae which this Committee evolved :

Average productivity per wagon day loaded with revenue earning traffic :

$$R_s = \frac{tkt}{N - (G + S) - 1 - A - \frac{P''}{V} - \left[(C' + D')\, W' + \frac{P'}{V} \right]}$$

Where A = annual number of wagon days empty, awaiting loading.
C′ = period for the loading of a wagon, from commercial stock with departmental traffic.
D′ = corresponding period for unloading.
G = annual number of wagons stabled.
N = operating number of wagon days.
P′ = annual distance travelled by commercial wagons in wagon/km.
P″ = annual distance travelled empty by commercial wagons in wagon/km.
S = annual balance of wagon days under the exchange system.
tkt = annual revenue of kilometric tonnage.
V = average commercial speed in km per day from its despatch to its delivery.
W′ = annual number of wagons from the commercial stock loaded and received loaded, with departmental traffic.

In turn, the factors N and V each require the resolution of formulae just as extensive as that for R_s above.

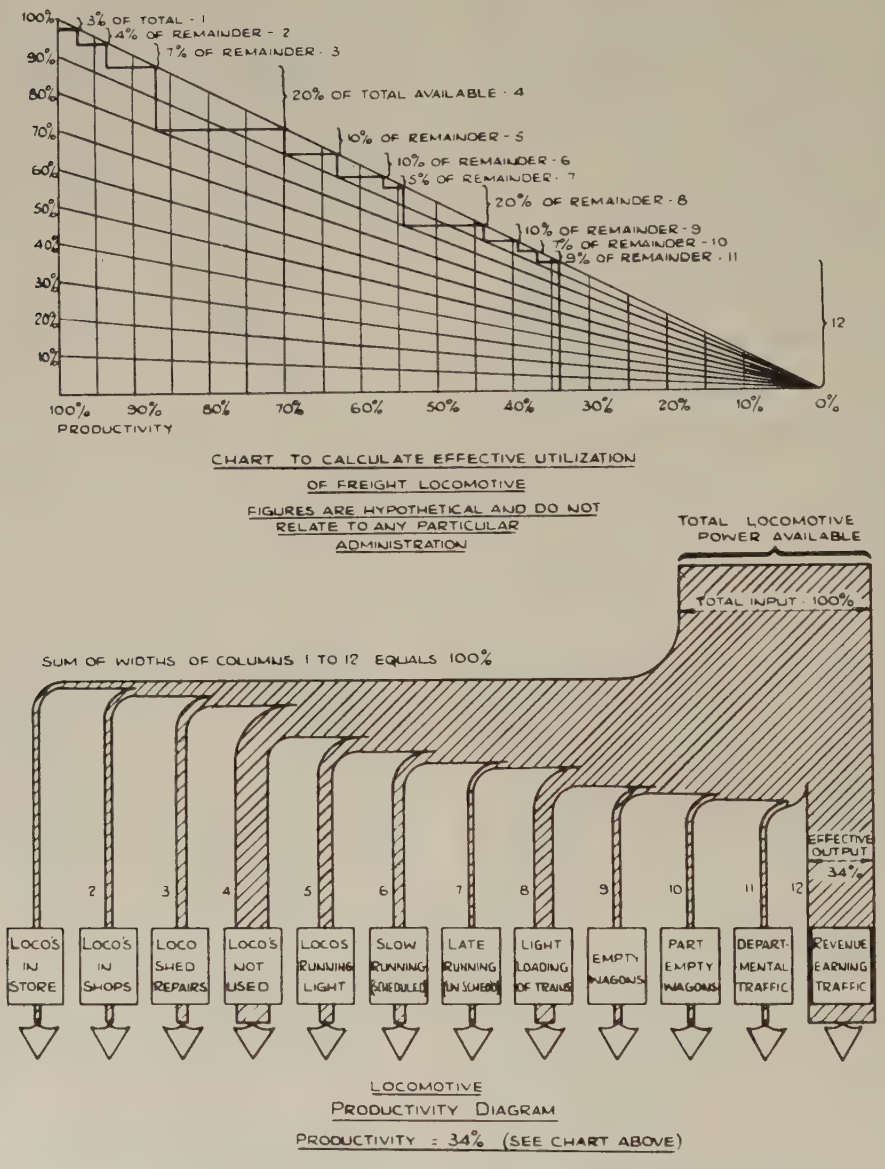

3% OF TOTAL - 1
4% OF REMAINDER - 2
7% OF REMAINDER - 3
20% OF TOTAL AVAILABLE - 4
10% OF REMAINDER - 5
10% OF REMAINDER - 6
5% OF REMAINDER - 7
20% OF REMAINDER - 8
10% OF REMAINDER - 9
7% OF REMAINDER - 10
9% OF REMAINDER - 11
12
100% 90% 80% 70% 60% 50% 40% 30% 20% 10%
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
PRODUCTIVITY
CHART TO CALCULATE EFFECTIVE UTILIZATION
OF FREIGHT LOCOMOTIVE
FIGURES ARE HYPOTHETICAL AND DO NOT
RELATE TO ANY PARTICULAR
ADMINISTRATION
TOTAL LOCOMOTIVE
POWER AVAILABLE
TOTAL INPUT 100%
SUM OF WIDTHS OF COLUMNS 1 TO 12 EQUALS 100%
EFFECTIVE
OUTPUT
34%
2 3 4 5 6 7 8 9 10 11 12
LOCO'S IN STORE
LOCO'S IN SHOPS
LOCO SHED REPAIRS
LOCO'S NOT USED
LOCOS RUNNING LIGHT
SLOW RUNNING
LATE RUNNING
LIGHT LOADING OF TRAINS
EMPTY WAGONS
PART EMPTY WAGONS
DEPART-MENTAL TRAFFIC
REVENUE EARNING TRAFFIC
LOCOMOTIVE
PRODUCTIVITY DIAGRAM
PRODUCTIVITY = 34% (SEE CHART ABOVE)

Fig. 3. — Productivity measurement. Illustration of the productivity of locomotive utilization.

On the face of it these calculations appear to be extravagant but upon closer study the factors are seen to take into account the very matters which are quoted as reasons for the discrepancies revealed in the small table for the five countries above. It would be unthinkable to compile regularly all the statistics demanded by these formulae and to make all the necessary calculations in respect of every phase of the railway industry. Nevertheless, the development of these formulae, the common understanding of their meaning, and an analysis of the results, cannot help but lead to conclusions of the greatest interest to those concerned in any part of the world with the efficient running of railways.

In connection with specific enquiries, such as those undertaken by Work Study teams, an analysis of productivity is essential. Furthermore, the actual studies taken of activities by means of *work measurement* and, in particular, *activity sampling* give a far more complete and reliable picture of the state of affairs in a particular depot or area. In the reply from the Netherlands Railways, the point is made that data necessary for specific investigations in that administration is collected according to need.

As a development of the use of graphic techniques of Work Study, it is possible to illustrate the facts revealed by such formulae as that quoted above. In a simple way the utilization of a locomotive, or of a gang of workers, may be represented on diagrams such as those in figure 3 and in Appendix I. It is not always appreciated that effective output is such a small proportion of input, and charts of this kind can be very revealing. The labour productivity may also be illustrated by means of labour control data which is drawn up with the concept of input and output and productivity indices in mind, and an example of this is also included in Appendix I.

British Railways produce no data specifically for the measurement of overall productivity, although some statistics which are used fall within the definition. At depot level, however, statistics of labour productivity are produced in the form of tons per man at Goods Depots, goods and miles per man or cartage rounds and wagons detached in yards. At national level there are several statistics of utilization per engine mile and so on. At local level, the increasing use of performance measurement by means of Work Study and labour control has provided a reliable measure of labour productivity.

The official view of this administration is that figures cannot manage, for the simple ones are not realistic, and the sophisticated ones are too complex for this purpose, and that because of complexity of service, productivity cannot be measured intelligently except at the level of individual labour performance.

The German Federal Railways recognise productivity measurement in four categories of their statistics.

(i) *Operating and Economy Ratios :*

$$= \frac{\text{Expense} \times 100}{\text{Revenue}} \%.$$

These have the disadvantages of failing to show where greater profit is possible.

(ii) *Productivity Ratios :*

For these, the monetary factor is eliminated, because it contains elements which affect the economic results of the undertaking from without and which have no bearing on the efficiency of the operations such as for example, the state of the market.

$$\text{Productivity} = \frac{\text{Output}}{\text{Man hours}}$$

An overall index produced in this way is of little value. The useful measure is in the details.

(iii) *Staff Performance Figures :*

$$\text{« Check Numbers »} = \frac{\text{Work Performed}}{\text{No. of Staff}}$$

Calculated per man and per shift for a great variety of duties.

(iv) *General Economy Indices.*

Based upon comparison of expenditure with services performed in each department of the administration. These are considerably sub-divided and are not all completed. These are continuously modified so that they reflect the latest position and any changes in productivity.

The Japanese National Railways by custom calculates its general efficiency by means of the ratio $\frac{\text{Expense}}{\text{Revenue}}$, its labour productivity by means of the ratio :

$$\frac{\text{Car km. in terms of 10-ton car}}{\text{Total number of Employees}};$$

its car utilization by the ratio :

$$\frac{\text{No. of cars in use}}{\text{No. of cars owned}};$$

and its locomotive utilization by the ratio :

$$\frac{\text{No. of loco's used}}{\text{No. of loco's assigned}}.$$

It also uses an efficiency index system for each Division which takes account of the amount of Traffic, the cost of moving it and the maintenance required.

The Norwegian State Railways establish annually the productivity ratios of Passenger Kilometres per man and Goods Ton Kilometres per man. It also produces technical ratios, such as axles per train, % empty run, and so on. This administration expresses a preference for simplicity and for data already in use for other purposes. It also favours factors related to distinct operations and to the persons in charge of them. It has recently begun to obtain more detailed productivity ratios.

The Swedish State Railways, besides compiling the conventional statistics, also concerns itself with « Work Productivity », « Energy Productivity », and « Rolling Stock Productivity ». This conforms with the opening remarks to this section of this report, in that these represent the productivity of labour, material (fuel) and equipment, respectively. The official national statistics of Sweden demand also figures of average numbers of staff per 10 000 train km, 100 000 axle km, 100 000 traffic km, passenger and seat km per axle km and paid seat km per route.

This administration also compiles annual « Station Work Figures » which are totals of units for tickets, goods, vans, trains and other factors multiplied by appropriate coefficients to reflect the work load of each. They have regarded this as a crude form of performance measurement which is not applicable to very large stations. They are now attempting to improve the measurement by means of « Norm Figures » based on time studies and correlative calculations. These are applied to large goods sheds, forwarding offices, motive power and carriage depots, and will eventually include ticket offices, other goods sheds, platform work and shunting, and all station duties. The intention is that these are aids to management planning and supervisory control.

Other administrations report mainly conventional statistics or indices based on conventional costing. The Bureau of Labour Statistics in America has included the productivity of « Rail Transport » in its studies. Measures of productivity on the railways in the U.S.S.R. appear to be mainly based on individual performance related to norms, on self costs at intermediate levels and on the broadest of statistics at national level. It may be noted here that the Soviet plan for 1960 envisages an

increase of labour productivity per head of 5.8 % which, on a basis of productivity per man hour, will require an increase of 10.5 % higher, it may be noted, than any of the figures quoted in figure 2.

The preceding outline of the development and theories of productivity measurement and the analysis and summary of the practices of railway administrations lead to a number of conclusions. The first is that the broadest ratios and the measures of productivity are of the greatest value, so long as it is well understood that they are broad. Likewise, the financial statements of profit and loss, as well as the commonly understood « Operating Ratios » must be included in this context. The limitations of these are the limitations of all monetary measurement where the value of money is subject to change and where the measurement of expenditure gives no indication of the scope for greater profit.

The limitations of physical measurement of the widely used factor of ton miles added to passenger miles per man hour are equally definite, but in another way. Scope for increased productivity is more clearly portrayed by analysis of these figures than by analysis of monetary figures. This is more the case when the analysis is not reversed because any attempt to synthesize the physical measurement in terms of common units bristles with difficulties. Your reporter is not at all impressed by the processes of the establishment of complex coefficients to be used constantly for the calculation of trends.

If the broader physical ratios are regarded intelligently they will be found of greater value to management in their bold simplicity then when confused by sophisticated mathematical calculations. These broader figures possess three aspects of merit. Firstly, they are of considerable interest when used in international and inter-regional comparison provided no suggestion of directly proportional interpretation is put upon them. Secondly, they are of value within a single administration, region or depot as an indication of trends of productivity. Thirdly, they are of the greatest value when used as the basis for such an analysis as that illustrated in figure 3, where the actual losses of utilization are derived. Similar analyses of the broader productivity measurements of a number of administrations would be of great interest, even if they were only to prove what has already been supposed to be the reason for the differences.

The question of analysis of productivity ratios leads to consideration of the details at the lowest end of the scale of activity. Measurements of the kind illustrated in Appendix 1, which are made most accurately with the aid of Work Study, present a system of *productivity micro-measurement* of the fullest meaning and value. It is to be hoped that *work measurement,* as described in subsequent sections of this report, may be practised more widely and used as a basis for labour control and individual performance calculation.

From this more precise approach, the connection between the broad measures and the details of the work at the level of the individual worker may be traced. Railway administrators may then be able to grasp more readily the fullest implications of technical change, increased individual effort, improved planning, and all other contributing factors of rising productivity.

The thoroughness and specific nature of productivity measurements which are based on the study of the work at the lowest levels call for some change of approach. It will be impossible to compile annual statistics of all such information with sufficient detailed accuracy to be useful. Furthermore, interest in such figures is not general and continuous, but is local interest on the part of managers who are concerned from time to time with particular problems of efficiency.

Much is to be gained from the comparison of specific analyses of productivity which have been made as the result of thorough and detailed investigation.

Comparison of performances, work specifications and standards as produced by Work Study will best reveal the nature of inefficiencies and the scope for increasing productivity. Accumulations of mathematically correct but fundamentally incomparable statistics can be of far less value than, for example, the details of methods and performances suggested by many of the brief case studies which are included in the final Appendix to this report.

3. ORGANISATION FOR WORK STUDY AND PRODUCTIVITY.

a) Work Study and Productivity Organisations.

The questionnaire submitted asked for descriptions of the organisations which existed in each administration for raising productivity and of those which existed for Work Study. It is worth recording that most railways which replied to the questionnaire in English had some section, office or department established with increased productivity as its object. This demonstrates the fact that railways throughout the world are conscious of the benefits to be gained from setting up organisations to increase their efficiency. Several administrations have gone no further than to establish normal production planning and control offices in their manufacturing workshops and one or two of these have interpreted Work Study as meaning nothing more. Whilst there are others who use Work Study techniques in these offices, there are many today who use Work Study also in various departments of their railways.

Eight of the administrations whose organisation for increasing productivity go beyond normal production planning and control in workshops, have given your reporter sufficient information for reasonably clear pictures of those organisations to be drawn. In Appendix II are presented diagrams and descriptions of organisations in Canada, Germany, Japan, Netherlands, Norway, South Africa, Sweden and the United Kingdom. An indication of the numbers employed for Work Study is shown where possible.

From these descriptions and diagrams it can be seen that the organisations differ greatly. There is no evidence to explain these differences but it can be assumed naturally that the reasons lie in the geography of the railway systems and the history of the development of the administrative organisations generally. Not all those illustrated are clear cut structures for Work Study alone, although most of them use Work Study in one way or another in their endeavours towards achieving higher productivity.

An important pattern emerges from the replies received. As a general rule the administrations recognise the desirability of Work Study Teams being responsible to line management on the one hand, and of having some central co-ordination and specialist advisory service on the other. The most clear cut structure on these lines is possibly that of the Canadian National Railways. In Japan, the Netherlands, Norway and Sweden, central co-ordination of Work Study appears to be divided. On each of these railways the department responsible for Railway Workshops has a separate Work Study structure : the Netherlands also have a separate office concerned with the productivity of the Commercial Department. Clearly, these divisions are the result of the workshops having developed production planning and control as a forerunner to Work Study probably long before it appeared elsewhere. It may well be that in those administrations, where individual departments have had particular concern for raising productivity prior to any concentrated action for Work Study, the problems of integrating and co-ordinating these offices have been greater. The explanation of the clearer structure in the case of Canada is that it was planned centrally as an all-line policy to supersede any beginnings of Work Study which might have appeared earlier in any department.

The compact nature of the six Regions

forming British Railways has enabled co-ordination between Regions and Headquarters to be closer knit by means of its Work Study Development Committee, a committee which meets regularly and on which each Division of the Commission is represented by a senior officer. It is fully appreciated that larger administrations, such as those of Russia or India, cannot in their Work Study organisations. The close relationship with research and planning is most marked in the cases of Japan and Germany, and Canada. In this latter administration, the central plan is again very clearly portrayed. South Africa and Norway have recognised the logical connection of these activities with the work of finance and planning.

Mobile Work Study Office.

A railway coach re-equipped to provide office accommodation for Work Study personnel at any station or depot where they may be working.

so readily co-ordinate activities by such a simple means. One feature which is outstanding is the manner in which several administrations have recognised the common purpose of all sections concerned with increasing productivity, irrespective of their different fields of activity. Sweden, Norway, Japan, Germany, Canada and Australia, have all accepted that studies of any type of office work are but a specialist branch of the Work Study activity and have incorporated sections for this work

b) Railway Productivity Councils.

British Railways and the Norwegian State Railways have both set up Productivity Councils. These are joint committees on which the administrations are represented, in the case of British Railways, by nine members consisting of Commission Members, General Managers and other senior officers and, in the case of the Norwegian Railways, by the Director General and by the Directors of the three

major departments. The Trades Unions are represented by an equal number for British Railways, who are normally Presidents and Secretaries of the larger Unions and by the Chairman and Secretary only of the Railwaymen's Union in Norway.

The British Railways Productivity Council meets monthly and has functions which are wider than is suggested by its title. Without executive authority or any concern with direct negotiation, it is free to discuss, advise and initiate proposals on all subjects. Whilst its ultimate objective is to increase productivity, its most useful means of achieving this is the easing of tension and clearing of misunderstanding which is provided by the regular meetings and frank discussion between leaders of management and staff. The Council visits railway installations, both at home and abroad, and also arranges visits of a comparable nature by staff representatives.

The Productivity Council of the Norwegian State Railways is the highest body concerned with matters of productivity. The duties of this Council and of bodies for productivity at lower levels within this administration are exclusively questions of productivity and Work Study; the manager of the Organisation and Methods Office is secretary of the Council.

c) Relations with National Productivity Councils.

The councils described, it will be noted, are similar to the National Productivity Councils which now exist in several countries today. The railway administrations were asked whether they maintained any relations between their own organisations for productivity and these national bodies. British Railways and the London Transport Executive are represented on the British Productivity Council by the Deputy Chairman of the British Transport Commission and on the Council's Work Study Committee by the British Transport Commission's Director of Work Study.

The Indian Railways are represented on the Indian Productivity Council by their Production Director. These administrations and also the Japanese National Railways and, sporadically, the Swedish State Railways, participate in the activities of their National Productivity Councils. The Norwegian Productivity Institute does not concern itself with transport, so that there, as in the Netherlands, the railways maintain no relations with the national body. There are no National Productivity Councils in South Africa, East Africa, Rhodesia, or in West Germany. In the latter case, however, the German Federal Railways are members of the Rationalisation Board of the German Economy and representatives of the railway take part in national activities which are directed at increasing productivity.

d) Use of Industrial Consultants.

It is not unusual for Industrial Consultants to be employed at the outset of any study into levels of productivity. Many of the administrations which have set up organisations for Work Study and similar objects took their first steps with the aid of consultancy firms. The establishing of training programmes for Work Study is one of the commonest ways in which consultants have been employed. They are also of value to a railway when a quite impartial review of its administrative structure is needed. With their broader knowledge of industry and their employment of men of high calibre, the consultants can sometimes produce results and changes which a manager inside is unable to see or bring about.

It appears that a few administrations have embarked upon the use of Work Study techniques without the aid of consultants, whilst it is common for their services to be dispensed with in all instances except for specific problems, once fully operative Work Study sections have been established. It is appropriate for any administration which proposes to employ industrial consultants, to obtain more than one estimate of the cost against a clearly defined remit in much the same way as they

would obtain alternative estimates when purchasing new equipment. It is undoubtedly very difficult to specify requirements before any study has been made : for this reason the advantages of an internal organisation of experienced staff cannot be overstressed. The cost, the time, and some indication of probable economies, are essential before embarking on an expensive detailed survey and possible application.

On British Railways, Canadian National Railways, Indian Railways, London Transport Executive, Netherlands Railways, Rhodesian Railways and South African Railways, various consultants have been employed for training staff in Work Study and for advising on initial steps in its implementation. On British Railways this work was quite extensive, but has gradually been reduced by means of a central advisory service operated by the administration's own staff. Consultants are employed very occasionally in Sweden for administrative problems and have been used in Canada for the installation of integrated data processing in the Accounting and Stores Departments of the Canadian National Railways. The East African Railways have not yet used consultants specifically for Work Study but have employed them for certain other enquiries which have involved the improvement of methods and the raising of productivity.

In West Germany consultants are employed for the development of new processes : in such cases they are generally members of the German Association for Work Study, of the Rationalisation Board of the German Economy or of engineering or consulting institutions. In Nigeria, consultants were employed but the project on which they were engaged was abandoned for lack of funds.

4. HUMAN RELATIONS FOR INCREASED PRODUCTIVITY.

a) Railways and Human Relations.

All the administrations agreed that the human factor is of prime importance amongst the factors contributing towards increased productivity. Five of them replied in such expressive terms that it has been considered worth-while to make extracts from some of these replies for inclusion in this report. These illustrate, more convincingly than your reporter can hope to do, the current trend of thought in railway administration on human relations.

German Federal Railways :

« For undertakings such as railways, which have service as their primary object, the economic success depends to a large extent on the efficiency of human work. « Men », as a factor of production, determine the quality and amount of these services at free will. It is this free will manifest in the willingness to serve and, in the end, deciding human efficiency, which should be guided in the proper direction. An important requirement is the creation and maintenance of a good social atmosphere within the organisation. Vital elements of this are fair pay, appropriate staff assignment, conferring of responsibility, just treatment, good relations amongst the staff and between superiors and subordinates. »

London Transport Executive :

« The product is service : 70 % of the cost is labour. »

Netherlands Railways :

« Even where no direct relationship between labour and production exists, the human factor will influence the results. In cases of extensive mechanisation or automation, the optimum performance of the equipment is still dependent upon human operation. The full co-operation of the staff for the introduction of measures to increase productivity can, as a rule, only be obtained when human individual and social needs are fulfilled. »

Norwegian State Railways :

« Employees nowadays are not employed and allocated without regard to their own desires and wishes. It is therefore of prime importance to create an atmo-

sphere of confidence between management and staff through democratic leadership for which continual collaboration based on full and frank mutual consultation is essential. »

Swedish State Railways :

« The connection between productivity and standard of living is clear to most people today. A greater improvement in the standard of living for all in the future will only be possible by means of a constantly increasing productivity... To create unity, the employees must acquire a feeling of confidence in their employment for the future. »

The Japanese National Railways regarded material factors involving the investment in physical assets as just as important for the increase of productivity in railway transportation.

The American Railroads are at present engaged in a strenuous attempt to correct an unsatisfactory situation which developed over a period of years. Known as « Featherbedding » it has every appearance to the outsider of extreme antagonism and clash of interests between management and staff. Nevertheless, Daniel P. Loomis, President of the Association of American Railroads, in a recent address has emphasised the point that management, in its attempt to rectify the position, is not attacking labour but labour legislation. He pleads for unity of purpose, saying that « only through the wholehearted co-operation of management, labour and public leaders can we hope to free the nation from the wastes of featherbedding » and increase productivity. A different viewpoint certainly, but a clear recognition of the importance of the human factor.

The U.S.S.R., whose railway administration is managed on the same principles as the rest of the nation, regard human relations as the natural outcome of their politics and socialist doctrines. Teaching, incentive and the entire organisation are built upon these ideals which themselves are founded upon consideration for human relations. This administration attaches great importance to, in the words of the questionnaire, « continuous action... to maintain the spirit of productivity and collaboration ».

The London Transport Executive claims a particularly enlightened record in staff relations and illustrates in its reply as near a genuine regard for its staff as any. It is undoubtedly true that the size of railway administrations can be a handicap in the achievement of the individual contact which so many of the administrations consider as essential. No doubt this has some bearing on the success of London Transport. In the words of the German Federal Railways « Contacting each employee direct ensures the most lasting effect ». In spite of every good intention, there is always the tendency in the larger organisation for an attitude which materialises in a collection of enlightened procedures and techniques, to degenerate into an inhuman application of these procedures and techniques for their own sake, with little understanding of the philosophy upon which they are founded. It arises from the fact that any discontent in a small organisation will be seen by the management whereas, in a large organisation, top management cannot always see what is happening lower down. It is of prime importance to develop a policy which encourages an atmosphere of mutual regard for each others point of view.

Some thirty years ago, reports in the Bulletin of the International Railway Congress Association told of the creation of systems for staff representation in a number of administrations. The « new status of railway servants » was proclaimed and joint councils for negotiation and discussion were established. More recently, the importance of joint consultation has been stressed. In some instances this has appeared as a result of a renewed statement of the attitude which produced the earlier staff representations, as if the earlier « machinery » had become too mechanical to be human.

Consultation procedures and organisations exist in all the more mature admin-

istrations. In some of the under-developed countries these are still not established, although the replies indicate that such are in hand. Whereas only a few railways possess variations of these for the sole purpose of promoting increased productivity, as described in the previous section of this report, almost all administrations use these consultative organs for productivity questions amongst other matters. In some cases, this has been taken for granted without any deliberate attention to productivity alone.

All administrations speak of the increasing awareness of the meaning of productivity and of the need for its increase. The Swedish State Railways list greater productivity, less variations in the product, reduced turnover, less sickness, fewer accidents, increased interest in work, improved co-operation, better spirit and more contentment. These aims and achievements are true of most railways in which, in the well expressed words of the Norwegian reply « the attitude towards productivity has gradually changed from resistance, to better understanding, collaboration, participation and acceptance ».

b) More Traffic or Less Staff ?

The questionnaire posed the dilemma which is often set by any increase in productivity, namely, the fact that the change in ratio of input to output calls for a reduction of input or an increase of output. One or the other is inevitable, and a reduction of staff or an increase of traffic are often difficult for a railway to achieve. An irresponsible management which dispenses with labour at short notice will quickly undermine any good relations which already exist and will inevitably slow down the increase in productivity. The inflexibility of its capital investment interwoven in a rapidly changing economy renders the attraction of greater traffic very difficult.

The only instance when a rise in productivity may be achieved without either an increase in traffic or reducing staff, is when the output is considered to include a measurable standard of service. In such cases the rise in productivity of this kind or a rise in efficiency will be absorbed by an improvement in the standard of service given to the customer.

The answers to this question showed, however, that this is not always the case. In the under-developed countries, traffic is still increasing. The expansion of services and of the railway itself is apparent in several countries. In the case of the workshops, as, for example, in India, an increase of the number of home-produced locomotives and rolling stock has absorbed all increases in productivity in these countries. In the U.S.S.R., each succeeding five-year plan speaks of increased expansion and of the need for further staff. In an attempt to illustrate the position of all those who replied, figure 4 shows approximately how some administrations have absorbed the increased productivity by increasing traffic and some by reductions in staff, and how some fall between these extremes. In no way does the figure indicate the extent of the increase in productivity :

In view of the anticipated unwillingness of administrations to undo the good work of their human relations policies by dispensing with staff and undermining their security, the questionnaire asked what guarantees were given in order to support this sense of security when staff reductions were inevitable. The commonest reply to this question was that no discharges were made as a result of Work Study or similar improvements, reductions being achieved as a result of natural wastage by retirement and normal resignations. It was admitted that transfers became necessary and that occasionally where a transfer was unacceptable to an individual, some local dismissals might be necessary.

In these cases, the human aspect was invariably carefully studied. The principle of « last in — first out » was common, preference being given to married employees, those with no domestic responsibilities being the first to be dismissed.

The Netherlands Railways personnel over the age of 55 are able to obtain discharge on favourable terms with full pay for one year, followed by 70 % until normal year of pension. In practice, this becomes necessary for only a very small number of Netherlands employees. Where a transfer cannot be arranged, an employee on this railway may be discharged at an early age, when he will receive 70 % of his pay for a period equal to his length of service if he is married, or for one year, if he is not.

On the Swedish State Railways, no financial loss is allowed as a result of transfer. In Norway the railway has agreed to retain redundant staff until the numbers are sufficiently reduced by normal wastage, transfers being facilitated by housing projects sponsored by the administration. The South African Railways sum up the position with the words « Generally speaking, the staff are aware that they can rely on the administration to cushion to the maximum extent the impact of the large scale changes that are taking place in the transport sphere ». In this connection six specific guarantees were quoted by this administration :

i) that wherever incentive schemes are introduced the basic wages will be maintained;

ii) that rates or time standards are never revised unless new methods are established;

iii) that an employee with two years' satisfactory employment becomes permanently appointed;

iv) that permanent appointment may not be summarily terminated except for disciplinary reasons or for early retirement;

v) that an annuity will be given after a qualifying period of service;

vi) that wages and salaries of permanent staff shall not be reduced without the individual's consent or by a general Act of Parliament.

Many of these guarantees, and several others which indicate a similar recognition of the rights of the individual, are to be found in other administrations, particularly amongst those on the right-hand side of the figure 4 which can be seen to have had to face up to reductions in staff, namely, the Netherlands, Norway, Sweden and the United Kingdom. Nevertheless, over the whole field, it is clear that the concept of justice towards employees and, what is more, of the need for more than justice, that is, for the need for human understanding, varies enormously. In each case where the guarantees or rights end, consideration for feelings must begin. No doubt these will culminate in guarantees, in course of time, because the rights of the individual are not inflexible laws for their own sake; they are but partial expressions of the spirit of human understanding. The rights of today are the result of yesterday's recognition of the feelings of the individual in particular circumstances. The rights of tomorrow can only be the result of today's recognition of those feelings. It can never be sufficient simply to recognise those rights : at all times there must be that genuine regard for individual feelings from which those rights have developed.

c) Maintaining Collaboration for Increased Productivity.

All administrations agree that continuous action is necessary to maintain the spirit of increasing productivity and collaboration. This action was detailed by some and outlined by others in answer to several of the questions in the questionnaire. There was a measure of duplication of questions on this subject, for your reporters envisaged measures of productivity and direct staff interest in its increase which would necessitate a clearer understanding and a more precise meaning than is apparent in the replies. It is possible to summarise the practices which were described under the general heading of managerial action towards maintaining collaboration for increased productivity.

The most positive step is that described in the preceding section of this report, namely, the formation of the single purpose

Diagram to illustrate solution of problem of increase in productivity.

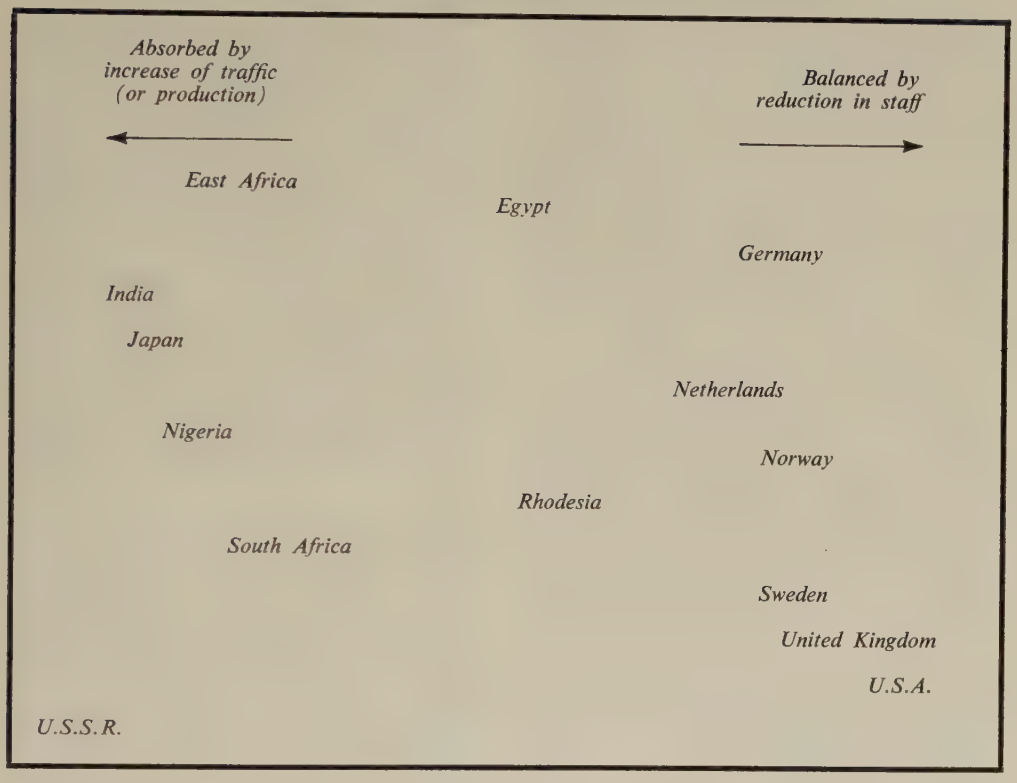


Fig. 4.

productivity council which exists in the Norwegian State Railways and, with broader scope, on British Railways. This high level informal gathering, by its freedom of expression, provides the most valuable means of maintaining an understanding between the management and staff. As a secondary measure, systems of joint consultation can serve an identical purpose generally at a lower level, providing the right spirit is engendered into the lower level of supervisor and the staff under them. These often follow the same pattern of organisation as the machinery of negotiation and, in so doing, run into constant danger of becoming similarly formalised. Generally, these councils are not devoted to questions of productivity alone; indeed, this topic is often taken for granted and when touched upon becomes the source of some misunderstanding.

Under the titles of Joint Production Committees, Works Committees, Staff Association Conferences, Consultative Meetings, and so on, such procedures are evident in nearly all railway administrations. In Ireland, the Railway Board is developing consultative procedures and, in Japan, it is understood that talks held to outline plans and hear views are being developed. In the Netherlands, Norway and Sweden, on British Railways, London Transport, and Indian Railways, in Germany, South Africa and Argentine, these media for discussion exist at one level or another.

If such meetings are to be fully con-

structive in their consideration of questions of productivity, it is essential for there to be enlightened common understanding of, not only the meaning and the implications of productivity, but also of the means by which it is achieved. The most positive action in this direction is the operation of full training courses and appreciation courses. Training for Work Study which, in its broadest sense, is the most practical approach to the questions, is dealt with separately in this report in a subsequent section. There are, however, a number of other training schemes through which the policy of increasing productivity may be promoted.

Consultative meetings are of greatest value when the atmosphere of common understanding prevails. This is always enhanced by the informality of the meetings. Often the most beneficial are regularly organised discussions without agenda or minutes between a local supervisor and his staff. The regular organisation of these is necessary to provide the continuity of contact which completely « ad hoc » discussions do not produce. Any changes in organisation, in working plans, or in methods which are envisaged, should be discussed frankly in this way from the earliest stages. What are the « earliest stages » is a matter for local decision, but in no case should discussion be postponed unnecessarily. There are circumstances where too early a statement of proposals may jeopardize the whole plan, but the rule should always remain that where in doubt discuss it with the men concerned.

Administrations have indicated the success of their consultation procedures at the highest level. All too often, however, it is difficult to ensure that the atmosphere of these meetings percolates to the corresponding discussion at the level of the worker himself. The solution to this problem lies in the supervisors. The essential attribute of any supervisor is that he should be capable of interpreting the desires and the attitude of management. An appreciation of the more enlightened human approach which this report advocates, should be included in organised training courses for supervisors.

Training courses for management, for supervisors, through Training Within Industry programmes and otherwise, and instruction and training of operators which becomes necessary for adapting staff to the changes brought about by technical development, rationalisation and increasing productivity itself, all provide the opportunities for imbuing employees with the real meaning of productivity.

Training programmes in East Africa have extended to some 3,000 supervisors who have benefited from T.W.I. In India, training courses for supervisors are run with aid from outside their industry. The Japanese Railways also depend for the dissemination of knowledge on such matters upon their supervisors who are specially trained.

On the German Federal Railways, there is a well organised training system for all branches of the service. This ensures a proper schooling in all new fields of activity, in new methods, and in questions of productivity. It is in keeping with the great strides which have been made in Western Germany for vocational training. In Norway and Sweden, training programmes are similarly extensive. In Norway, training programmes are organised for various branches with emphasis on management and supervisory training, yet the administration maintains that there is still much to be done in this direction. In Sweden, there are some sixty established programmes for training in occupational spheres. These follow the pattern of fundamental training followed by vocational training. Where new methods are introduced, complementary courses are run. Systemisation of training is being carried out in order that Training Within Industry may be used based upon thorough analysis of the work to be performed. Special training and selection for leadership is undertaken. In South Africa also training programmes are extensive, and at management level bursaries are provided to enable officers to receive university training in the various fields of management.

On British Railways several training colleges have been in operation for many years. The Work Study Training Centre is described more fully in another section of this report. The organisation as a whole provides for vocational training, background training, voluntary training and further education. Questions of productivity are the direct concern of the Central Work Study Training Centre and of the Regional Work Study Schools and they also appear indirectly in the programmes of other colleges. In particular, the B.T.C. Staff College for Higher Management devotes some of its time to consideration of various methods of improving productivity.

Training is also referred to in the reply of the Netherlands Railways and of the Rhodesian Railways. In Nigeria, it has been considered.

After consultation and then training, the third medium for active propagation of the principles of productivity and for the development and maintenance of the spirit of collaboration in which it thrives, is that of publications and literature generally. Direct information to all staff is offered by means of management and Trades Union periodicals and journals in India, Netherlands, Norway, Sweden, West Germany and the United Kingdom. At supervisory, middle management and higher levels, British Railways make full use of the excellent publications and films of the national British Productivity Council.

In West Germany, posters are used to advance the principles of increasing productivity. It is generally known that in the U.S.S.R. appeals for higher productivity are widely used in the form of posters and other displays.

The publication and posting of graphs, which illustrate to staff the trends of rises and falls in traffic, or in work carried out, are at the local level a real incentive to higher productivity. A more extravagant, but effective visual aid to publicity, is that of the industrial film. Many excellent films have been made which illustrate most railway activities and means of improving efficiency.

It should be noted that in each of the three stages of action described for maintaining collaboration for increased productivity, the distance between management and staff widens from the close contact of consultation to the somewhat one-sided relationship provided by publicity campaigns. To counterbalance this trend, there exists the cogent need of communication in the opposite direction. This is most effectively provided by suggestion schemes, which are described at length in the following pages.

The Nigerian Railway Corporation is the only one in which the staff is not in a position to make observations and criticisms regarding suggestions. All other administrations which replied to the questionnaire claimed that there was adequate provision for this return of views from staff to management. At the same time it must be realised that the majority of individual administrations are state owned, with the result that the distinction between management and staff is not as real as it was originally. At each level in the structure of an organisation, the individuals have interests with the staff on the one hand, and with management on the other. For this reason, action for maintaining the collaboration of staff cannot be directed solely to the lowest levels. Consultation, training and publications are of equal value and often of greater value when offered to management itself. Similarly, this consideration for human feeling and the need for personal contact and understanding are of equal importance at this level.

d) Suggestions Schemes.

Most of the administrations which replied to the questionnaire in English operate schemes whereby suggestions made by railway personnel are judged and awards made. The German Federal Railways emphasise the fact that each employee is called upon to consider how his work can be performed faster, cheaper and with greater safety. In the U.S.S.R., the rewarding of workers who make proposals for the improvement of output or the rationalisa-

CNR-9750 BACK END

SUGGESTION

DO NOT WRITE HERE

DATE

HA No. 1834

WHAT SHOULD BE DONE ▶ *I suggest that* _____

DETAILED DESCRIPTION (ENCLOSE SKETCH FOR CLEAR UNDERSTANDING OF IDEA)

HOW
SHOULD IT BE DONE ▶ _____

WHERE
SHOULD IT BE DONE ▶ _____

WHY
SHOULD IT BE DONE ▶ STATE THE BENEFITS ▶ _____

YOUR SUPERVISOR CAN BE OF ASSISTANCE. DISCUSS YOUR IDEA WITH HIM, WRITE IT DOWN IN THE SPACE PROVIDED AND ASK HIM TO FILL IN THE FOLLOWING:

SUPERVISOR'S COMMENTS

I HAVE ☐ PUT THE SUGGESTION INTO EFFECT ☐ ELIMINATED THE PROBLEM BY OTHER MEANS AS A RESULT OF THIS SUGGESTION ☐ NO JURISDICTION OVER THIS MATTER

SUPERVISOR'S SIGNATURE ▶ TITLE ▶

SUBMISSION TO THE COMPANY OF THIS SUGGESTION CONSTITUTES ACCEPTANCE OF THE CONDITIONS OF THE SUGGESTION PLAN AS SET FORTH ON THE REVERSE SIDE.

EMPLOYEES' IDENTIFICATION (AVOID USING ABBREVIATIONS)

FULL NAME (PRINT)_____ SIGNATURE ▶_____

OCCUPATION_____

DEPARTMENT_____

LOCATION_____

DATE_____

POSTAL ADDRESS_____
THIS NEED NOT BE FILLED IN UNLESS YOU WISH US TO USE YOUR HOME ADDRESS.

NOTE: IF YOU WISH YOUR NAME WITHHELD, PLEASE CHECK HERE ☐

KEEP THIS STUB

IT IS YOUR RECORD OF THE SUBJECT AND DATE AND NUMBER OE YOUR SUGGESTION.

SUBJECT_____

DATE FORWARDED_____ 19____

DATE ACKNOWLEDGED BY SUGGESTION OFFICE_____ 19____

HA No. 1834

▲

SHOULD YOU WRITE TO THE SUGGESTION PLAN OFFICE USE THIS NUMBER

Fig. 5.

tion of work springs naturally from the socialist principles upon which their labour code is founded. Several administrations publish or display on posters leading questions such as « Where is that job done and why is it done there? ». These are intended to develop a questioning mind on the part of the employee which is the more likely to produce ideas.

The Canadian National Railways attaches great importance to publicising its scheme and encouraging its personnel to use it. In this administration the staff are persuaded to discuss their ideas with their Supervisor. In this way, it is hoped that the open discussion will do much to develop a creative atmosphere in which labour and supervision strive with management to rationalise their work methods. As an added inducement to employees, the forms upon which suggestions are to be made are carefully designed to guide those with ideas into making the most constructive suggestions. A copy of the Canadian form is included in figure 5.

All administrations judge suggestions by means of committees which draw upon the specialist or local knowledge of the appropriate departments or to which the suggestions relate. In India, Norway and Sweden the committees are joint ones upon which the staff and management are fully represented. Other countries confine these committees to management in that they generally consist of senior officers drawn from each leading department. The advantage of the joint committee is that it satisfies any need that there might be in some administrations for justice to be seen to be done.

It appears that no administration bases the size of the award on estimated savings alone, although the South African and the East African Railways usually give an award equal to 5 % of the total savings for the first three years where economies are effected and savings can be calculated. Nevertheless, it is clear that the financial value of any suggestion is of prime importance in assessing the approximate size of the award. The Japanese National Railways were the only ones to mention, specifically, additional revenue as one of the factors considered in judging suggestions. In this case a point system is used which takes into account a number of factors, including additional investment required and originality.

Amongst the other bases of calculating awards which were found were : merit, the stage to which the idea is developed, the existence of similar suggestions, the need for the award and the encouraging effect which it might have on the employee. In one case the award was said to be merely nominal, whilst in Nigeria the awards are graded into five categories according to the value of the suggestion.

Insufficient information has been received for any analysis or summary of the size of awards to be made. It appears, however, that they range from a sum equal to about one-tenth of the employee's weekly wage for meritorious suggestions which are not necessarily adopted, to as much as a hundred times the weekly wage where the suggestion has proved to be extremely profitable to the administration. The East African Railways makes the point that awards are recommended by the committee and are granted only at the discretion of the General Manager. On British Railways a number of special additional awards up to about ten times the weekly wage are paid for the best suggestions of the year.

An example of the principal statistics which are published annually in regard to suggestion schemes on British Railways is given below :

Total Number of Suggestions received	6,909	
Number of Suggestions approved	693	
Total Awards for Suggestions Approved		£2,034
Number of Suggestions of Interest	452	
Total Awards for Suggestions of Interest		£ 549
Total Sum of Awards		£2,583

Where suggestions are rejected it is customary to offer explanations to the employee. British Railways are particularly careful in this direction; reasons for not adopting a suggested change of railway working are often complex and are described at length. This is an important factor in dealing with suggestions. If a scheme is to be of value in inspiring the staff and interesting personnel in increased productivity, the organisers of the scheme must give every indication of efficiency in their own work. Where it is necessary for a suggestion to be tested in practice before its value can be assessed, British Railways make a point of informing the employee and, occasionally, of making an interim award. Although no facts were gathered with regard to this aspect, it is your reporter's view that suggestions which remain unrewarded or unanswered, save by a formal acknowledgment, for more than three months are likely to cause more discontent than encouragement.

It is consistent with the operation of a suggestions scheme, which is designed both as an outlet for ideas which are all too often suppressed by large scale organisations and as a means to interest the staff in higher productivity, for the scheme to be well publicised. Advertising the scheme itself has already been mentioned. A second aspect of publicity lies in the announcement of the suggestions themselves. Although it is customary for the identity of the employee to be concealed should he so desire, it is of great value if his name and his suggestion can be given publicity wherever possible. The difficulty largely disappears where equipment and material is involved, rather than staff. On the South African Railways, except where anonymity is specially requested, all suggestions are published in the General Manager's Weekly Notice, whilst the Canadian National Railways issue an Award Bulletin for the same purpose.

Not many administrations have referred to the question of the eligibility of the different levels of receiving awards for suggestions. It is usual for Supervisors, Methods Engineers, Draughtsmen, and others whose job it is to formulate ideas, to be regarded as ineligible for awards for suggestions made in regard to their own type of work. Without publishing any rules on the matter, British Railways maintain the policy that, except in these obvious cases, no employee is excluded from the scheme. Other administrations specifically exclude certain suggestions, for example, non-constructive complaints and letters which draw attention to minor clerical errors.

The South African Railways treat suggestions and inventions together and attach their general regulations regarding « Letters Patent » to their instructions on suggestions. This administration takes a generous view of patent rights. Not only does it assist the employee to obtain Letters Patent, where it regards such a step as worth-while, but it allows the employee complete freedom to dispose of his invention subject to the execution of a free licence to the administration to use the invention without payment of royalties. This is regarded as a logical extension of the philosophy of their suggestions scheme in that the encouragement that the chance of a full reward for an invention will give an employee might well be of greater value to the administration than any coincidental royalties.

Summing up the thoughts expressed in this section on human relations, it can be said that all measures for improving such relations and for developing the individual's interest in his work have the effect of raising productivity. Working conditions generally, amenities, safety, uniform and protective clothing, welfare, wages, and all such features of employment, some of them small items in themselves, do collectively determine for the worker whether his job is attractive or not. With rising world standards of living, administration must keep pace with modern standards. This is all the more necessary for railways, where the nature of the work is exacting in its irregular hours of work, in its continuation when others are on holiday, and in

the need for many to operate in the open in all weathers. Conditions for railwaymen may need to be higher than average to compensate for these inherent disadvantages.

Behind all these physical manifestations there lies the spirit from which they have emerged. It is essential that this spirit should keep pace with the material standards. No improvement should be given grudgingly as a reluctantly admitted right, but should be introduced consciously as a calculated contribution to ensure that each employee recognises the fact that he is needed and that his feelings are considered. Springing from such an atmosphere, even the smallest improvements in working conditions will have a material effect upon rising productivity.

5. WORK STUDY.

a) Definitions and Developments.

As explained in the introduction to this report, a concise definition of Work Study was given in the questionnaire. This definition is repeated here :

« Work Study is defined as the critical examination of any work with a view to making the most economical and effective use of men, materials, equipment and buildings. »

This definition was supported by the remarks :

« Improvements do not necessarily have to be obtained by the installation of new and costly equipment; improvements of some magnitude can often be secured by analysing the process and operations carefully, eliminating unnecessary work and motions, and instituting simple practical work-reducing methods. There is just as much scope for Work Study in non-technical departments as there is in technical departments : it applies equally to office work. »

To those countries which are familiar with the techniques of Time and Motion Study which have been developing gradually for the last forty years, these definitions were clear. Those, in particular, which are using the latest developments of these techniques which have recently spread more rapidly under the single term of Work Study, have been able to answer all the questions. There are a few administrations, however, which do not use such techniques of management and from whom the questions evoked descriptions of production planning and control and piecework systems which have been but the forerunners of Work Study where it has been used elsewhere. Such systems are by now almost universal and much has been written on them. Although several of them have incorporated many of the principles and practices of Work Study, it is not proposed to deal with detail production planning itself in this report.

As mentioned in the previous section, several administrations have a separate organisation for handling Workshop productivity. Germany, Japan, Netherlands, Norway and Sweden have all used Work Study in varying degrees in this direction for some years.

In Appendix III are tabulated the dates when Work Study was first used, as well as the leading facts about the practice of Work Study in each administration. From this it can be seen that almost every aspect of the railway operation has, in one country or another, been subjected to the critical analysis of Work Study.

In Appendix VI are given thirty examples of the application of the scientific organisation of work of the kind commonly achieved with the use of Work Study. These brief case studies are drawn from examples offered by those administrations which replied to the questionnaire in English. They all tell a common story of success and together show how widely the techniques of Work Study have already been applied to railway work. The nine categories into which the case studies have been classified cover all the principal activities of the average railway administration. Examples were offered also of similar application to ancillary activities such as docks, catering establishments, railway laundries and road transport services.

The pie diagram in figure 6 is a hypothetical case of a railway illustrating the labour cost as apportioned to these same categories of activity. Such an illustration would be of value in determining the priorities for the application of Work Study in an administration. Progress in the application of Work Study cannot readily be assessed, but from reading these the earlier fruits of scientific organisation in the form of production control and piecework systems and have either not considered it necessary or have not found it possible, due to long established practices, to take full advantage of the more advanced Work Study techniques.

In Germany, it is interesting to note that developments have turned full cycle

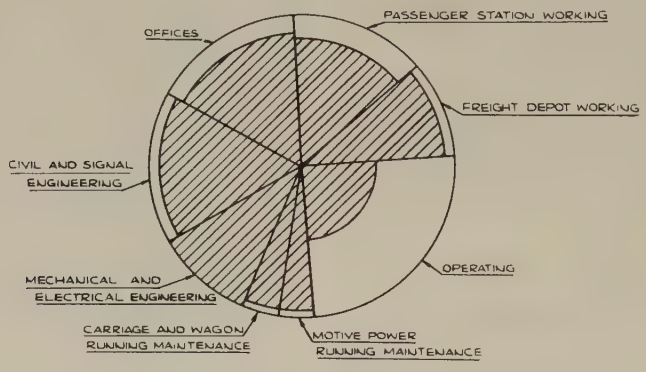


DIAGRAM TO ILLUSTRATE THE SCOPE FOR WORK STUDY ON RAILWAYS

I THE TOTAL AREA OF EACH SEGMENT REPRESENTS THE RELATIVE LABOUR COST IN EACH CATEGORY OF ACTIVITY IN A TYPICAL RAILWAY ADMINISTRATION

II THE SHADED AREA REPRESENTS THE ESTIMATED SCOPE FOR WORK STUDY IN EACH CATEGORY

Fig. 6. — Diagram to illustrate the scope for Work Study on railways.

case studies and other reports, and from a close study of the replies contributed by administrations, your reporter has been able to indicate very approximately, by the shaded area of each segment, the extent of applied Work Study in the eight categories which are illustrated.

It appears that Work Study in its most advanced form has, interestingly enough, been applied as much outside Workshops as within. There is evidence that Workshop managements have been content with from the application of *time and motion study* in the 20's and 30's to the broader attention of rationalisation in more recent years, followed by renewed attention to the details of activity in the last three years by means of advanced Work Study. There is no doubt that this pattern of carrying out major improvements towards higher productivity with a sound basis of detailed study must be traced repeatedly. Attempts to rationalise and reorganise without a clear and factual understand-

ing of the basic tasks which can only be provided by Work Study are likely to lead to difficulties.

Work Study lends itself most readily to those activities which involve a high proportion of physical work. This is realised in railways in the number of applications to goods and parcels handling. There is scope also in other depot and station duties, particularly on the broader scale of work planning and staffing. In these cases the fluctuations in work load and the need for some reserve to guarantee adequate service to passengers and traders, allow more limited scope for the finer techniques. On the operating side the greater physical activity and scope for Work Study lies in shunting and marshalling. Studies of yard working, coupled with rationalisation of freight train operation, would appear to offer the greatest opportunity for increasing productivity.

There are no reports of effective applications of Work Study to passenger operation beyond *activity sampling* and design of amenities. This is probably the field for Operational Research and Market Research in that much of the actual work to which Work Study would normally be applied is performed by the trains and by the passengers themselves. Some scope for Work Study lies in the smaller and more isolated tasks such as train preparation, but applications here will have small effect upon the productivity of passenger train operation as a whole.

It is important to give consideration to the most profitable activities for the application of Work Study so that the resources of trained staff may not be wasted on studies of limited value. Generally, these are jobs which are bottlenecks restricting productivity over a wide range of work, are laborious, dangerous or dirty and therefore unpopular, or are costly because of the large quantity involved, because of expensive equipment required, or because of the value of the item being worked upon.

In more than one reply reference was made by administrations to the « Introduction of Work Study » published by the International Labour Office and to the « Glossary of Terms in Work Study » published by the British Standards Institution. There are some minor differences between these two publications, but generally they describe an identical collection of techniques which have been adopted by Work Study practitioners almost universally. Work Study, with its consideration of the individual who is doing the work, is certainly more than the execution of techniques, but these are the most conspicuous and tangible aspects of its practice; it can for the most part be regarded as short term research.

b) **Method Study.**

As can be seen from Appendix III, *process charts, flow diagrams* and *time study* are the techniques most commonly used. *Process charting,* in which the sequence of events is portrayed diagrammatically by means of standard symbols, is of considerable value in the analysis of an operation in which there are many separate jobs to be done and moves to be made. An example of extracts from a *process chart* is included in Appendix V. This is taken from a study made by the Canadian National Railways of the assembly of alternator and compressor units. The symbols used are almost the same as those used elsewhere, and the chart must by typical of many of those referred to in the replies from other railways. An important point to note is the fineness of the analysis which it illustrates.

The definition of Work Study already quoted spoke of critical examination. Such a phrase does not reveal the degree of analysis which can only be demonstrated by such examples as this. Those who are accustomed to normal industrial process planning will see that the *process chart* takes account of much greater detail than has usually been the custom. To the Work Study practitioner this degree of analysis is still coarse, for he has in his hands the finer analyses which meet the needs of accurate *work measurement* in which ele-

ments of 20 sec are the rule and elements as short as 5 sec are not uncommon.

The second technique, the *flow diagram,* is a plan of a workplace with the movement of men, materials or plant drawn on it, and is of the greatest value in planning the layout of a workshop, depot or station. Two examples are given in this report in Appendices VA and VB which show the layout of a workshop before and after study. The charts are self-explanatory if taken together. The reduction in movement is not as pronounced as can sometimes be obtained, but there is no doubt that without the charts it would have been extremely difficult to perfect the layout with any confidence.

It is often the case that *flow diagrams* used as an aid to shop layout are best produced on a squared background so that distances may be readily seen and actual positions on the shop floor quickly plotted. The addition of simple scale models in two or three dimensions of the various pieces of equipment is of considerable assistance in this respect. This appears to have been adopted in the example illustrated by the Canadian National Railways.

The *string diagram,* which is a more vivid form of *flow diagram,* is used in Ireland and Rhodesia and occasionally by British Railways. The view of one or two other administrations is that it is rather clumsy for general use. It is certainly of value when a simple and effective visual aid is required to emphasise the distance which can be travelled over a relatively small area. Such charts are invaluable in demonstrating to management and men the improvements envisaged. Skilled operators are not required for unnecessary walking. The photographs of string diagrams show their use in connection with the overhaul of gear boxes for Diesel vehicles.

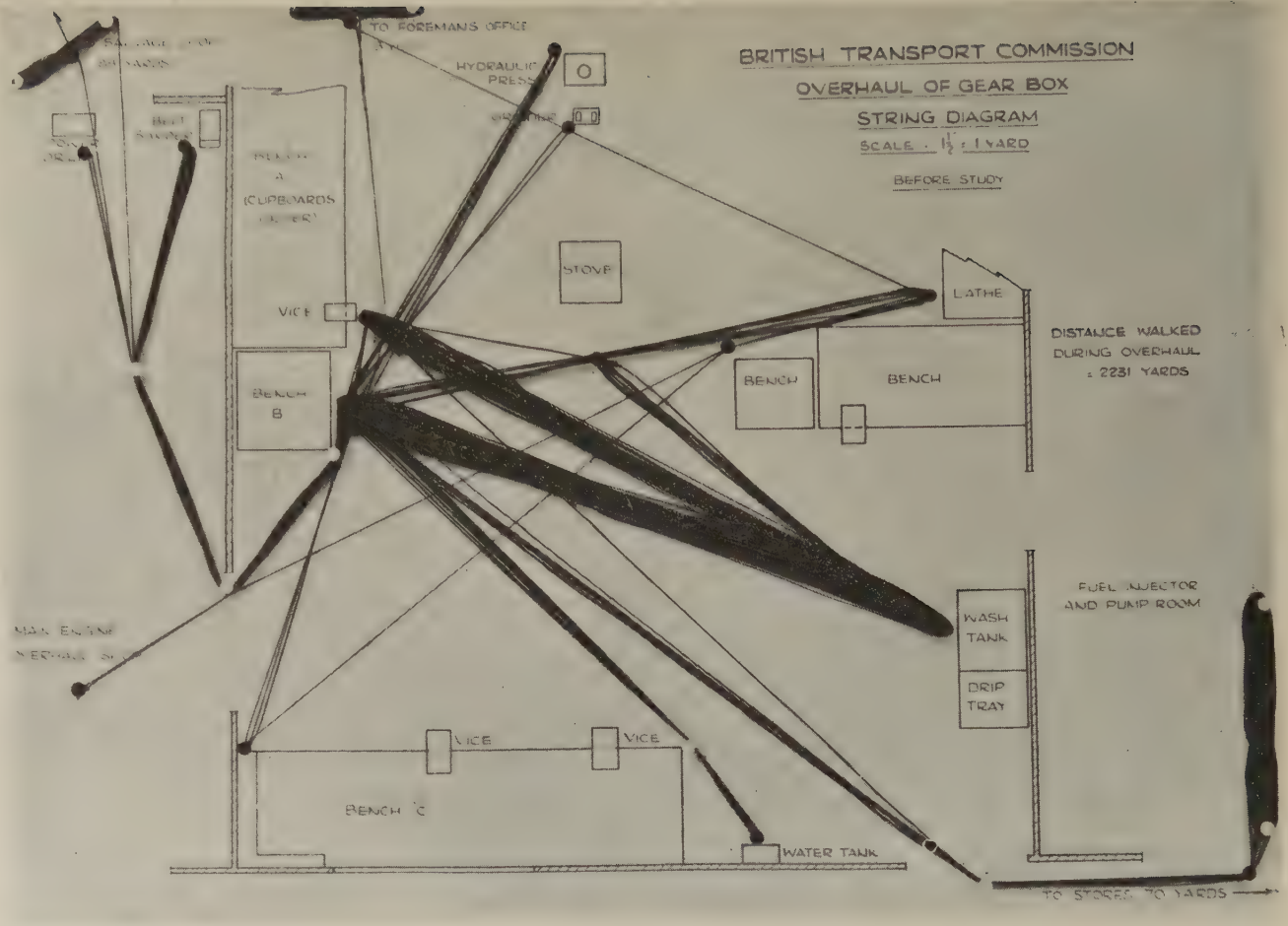
Neither the *process chart* nor the *flow diagram* are suited to illustrate the time taken by an operation, or parts of an operation. The *multiple activity chart,* which is an adaptation of the normal time-table or work diagram, does this very clearly. The example in Appendix VI A is taken from the reply of the Japanese National Railways. It is an extract from a chart which that administration is using extensively in connection with its studies of station working and is one which can be fully commended.

It is similar in principle to that used by British Railways, which is illustrated in Appendix VI B. This latter example is fully explained, together with additional diagrams which have been produced from it in Case Study No. 2 in Appendix VI. Activity charts are also used in Appendices I and VI D.

In addition to these techniques reference has been made to *memo-motion* or time-lapsed photography, which is a fixed interval filming technique. Pictures can be taken, say, at one second, five seconds or larger intervals and then the film run through at normal speed. A surprisingly large number of administrations expressed their intention of using this medium but no examples of its use have been given. There is no doubt that in the railway industry there is considerable scope for such a means of recording at predetermined intervals, not only movement, but also the state of a work-place or other activity over a period of time. It offers great possibilities and may well replace a number of trained observers in certain instances. It is probably its novelty and the local resistance by operators to the unseen eye of the camera that has delayed its universal introduction.

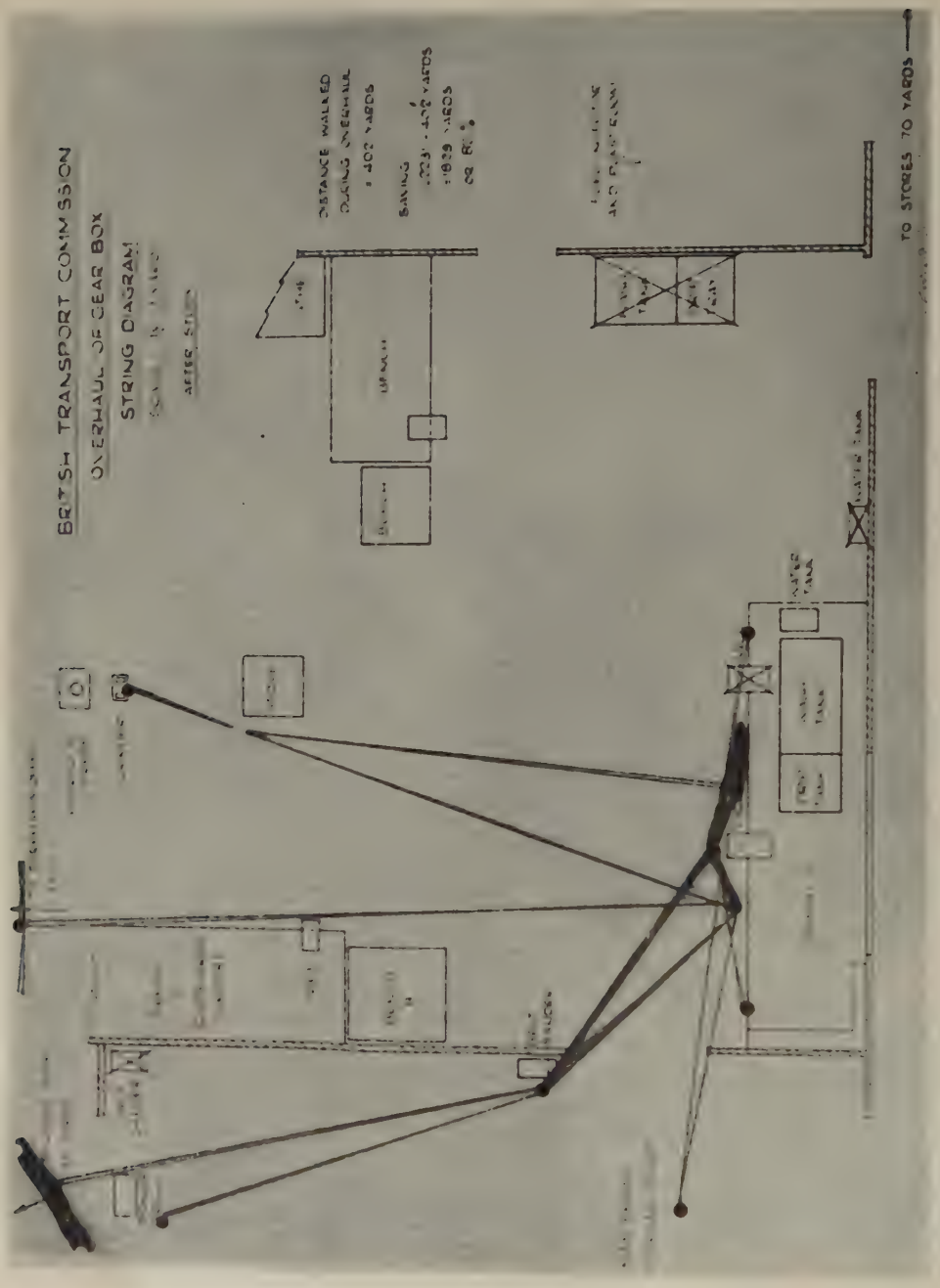
c) Work Measurement.

Work measurement is complementary to *method study* which has already been described. Almost all administrations claim that they use *work measurement.* On its own there is nothing to distinguish this from ordinary timing of an operation. It is the adjustment of the observed time according to the observed speed of work and the addition to that adjusted, or basic time of some allowance for fatigue and other factors that constitute the special



String Diagrams I and II.

Diagrams constructed with pins and string to illustrate the actual movement of men, materials or equipment in the course of an operation. The two diagrams show vividly that the method study has enabled the distance walked by a skilled fitter to be reduced by 82 %.



String Diagram II.

characteristics of *work measurement* as used in the context of Work Study, and place it in a different category from ordinary timing.

Appendix III indicates the various practices of the administrations. By far the greater number use a rating scale for judging the observed speed of work and for adjusting the observed time to basic time in which the standard speed of work is represented by 100 and complete inactivity by 0. Where work is done with an adequate motivation as, for example, by means of a financial incentive bonus which equals a quarter or a third of the daywork wage, the rate of working is regarded as this 100 or standard. In the case of the Canadian National Railways, where no bonuses are paid for measured work, a performance of 80 is required on the 0-100 scale. In other administrations 75 is generally regarded as the daywork rate.

India and South Africa, and some of the earlier sections of British Railways, use the 60-80 scale in which 60 and 80 correspond to the 75 and 100 respectively on the commoner scale. The Irish Railways use the 100-133 scale of rating with the same corresponding standards.

Administrations were not asked at what rating or performance their times were finally recorded. The British Standard practice is for them to be calculated at the time taken at 100 or Standard Performance and this appears to be the accepted practice in many other countries.

All administrations using Work Study add some allowance to the Basic Times for effort and conditions of working. These allowances differ slightly in their application, but as can be seen in the table, the average is 15 % with a range from 0-5 % for very light work to 30 % or more for specially laborious and heavy work.

d) Activity Sampling.

The technique of statistical sampling of work is one which is becoming increasingly popular. As Work Study is extended into broader fields of industrial activity the accepted means of carrying out *method studies* and *time studies* is seen to be most expensive if not virtually impossible. The railway industry is a particular case in point. With a high proportion of the work requiring the employment of small teams of men — in train and shunting crews, goods handling, permanent way gangs and so on — and with many of these spread over large areas and constantly moving from one work place to another, conventional studies become unsuitable. Under the names of *ratio delay studies, work sampling, observation ratio study, frequency study, random observation study* and *snap reading,* the technique now defined by the British Standard Glossary as *activity sampling* is already in use in no less than eight administrations. It has much to commend it.

By means of statistical probability calculations it is possible to calculate the number of observations or readings required to state the results with a particular accuracy or within particular « confidence limits ». The formula commonly used and derived from first principles is :

Number of observations required =

$$n = 4 \frac{(1 - p)}{s^2 p}.$$

Where s = the allowable percentage accuracy;

p = the percentage occurrence of the activity being measured.

In order to calculate the number of observations it is first necessary to assess broadly the probable frequency of occurrence of the activity to be observed. Once the study is under way these figures have to be recalculated. From the examples given in figures 7 and 8 the value of the technique is most evident. In the first example, which shows a selection of records of the use of passenger station facilities by passengers at a particular station, the confidence limits are shown. These indicate the accuracy of the results over the period of study. The second example,

Example of activity sampling : Passenger activities on railway stations.

Booking office windows.

Window No.	*In use by*				*Closed*
	No. Passengers	*1 Passenger*	*2-5 Passengers*	*Over 5 Passengers*	
1 Observations	128	129	145	11	3
Percentages	31	31	35	2	1
Confidence limits ±	4.5	4.5	4.6	1.4	1.0
2. Observations	12	25	14	—	365
Percentages	3	6	3	—	88
Confidence limits ±	1.6	2.3	1.6	—	3.1
3. Observations	1	1	—	—	414
Percentages	—	—	—	—	100
Confidence limits ±	—	—	—	—	1.0
4. Observations	315	74	23	—	4
Percentages	76	18	5	—	1
Confidence limits ±	4.2	3.7	2.1	—	1.0
5. Observations	252	116	45	2	1
Percentages	60.6	27.9	10.8	0.5	0.2
Confidence limits ±	4.8	4.4	3.0	—	—

General enquiries.

	0	*1 person*	*2-5 persons*	*over 5 persons*
Passengers being served				
	53	268	95	—
Percentage	12.7	64.4	22.9	—
95 % C.L. ±	3.2	4.6	4.1	—
Passengers waiting				
	141	80	162	33
Percentage	33.9	19.2	38.9	8.0
95 % C.L. ±	4.6	3.8	4.7	2.6

Fig. 7.

Seat reservation office.

	Passengers being served				*Passengers waiting*			
	0	*1*	*2-5*	*Over 5*	*0*	*1*	*2-5*	*Over 5*
Pullman services								
	144	253	19	—	281	68	44	23
Percentage . . .	34.6	60.8	4.6	—	67.6	16.3	10.6	5.5
95 % C.L. ± . .	4.5	4.7	2.0	—	4.8	3.6	3.0	2.2
Other services								
	151	208	56	—	259	35	105	17
Percentage . . .	36.4	50.0	13.6	—	62.3	8.4	25.2	4.1
95 % C.L. ± . .	4.7	4.9	3.4	—	4.7	2.7	4.2	1.9

Left luggage office.

	Passengers being served				*Passengers waiting*			
	0	*1*	*2-5*	*Over 5*	*0*	*1*	*2-5*	*Over 5*
Totals	94	157	165	—	268	56	77	15
Percentage	22.6	37.7	39.7	—	64.4	13.45	18.5	3.65
95 % C.L. ± . . .	4.0	4.8	4.8	—	4.7	3.4	3.85	1.90

Waiting room No. 1 platform

	In use by -				*Total*
	0	*1 person*	*2-5 persons*	*over 5 persons*	
Total occasions	69	65	228	54	416
Percentage	16.5	15.6	54.8	13.1	100
95 % C.L. ±	3.5	3.5	4.9	3.3	—

Fig. 7 *(continued)*.

Example of activity sampling : Goods depot working

Grade	*Working or not working*	*Activity*	*No. of observations*	*Percentage of total*
Porters	Working	Preparing wagon	51	3.6
		Positioning barrows and loading	166	11.7
		Barrowing	591	38.2
		Unloading at trailer	119	8.4
		Other work	133	9.4
	Not working	No work available	118	8.3
		Waiting for Checker	125	8.8
		Waiting because of traffic blockage	45	3.2
		Other causes	27	1.9
	Away from platform		91	6.4
	Total observations		1 416	100 %
Van Unloaders (Checkers)	Working	Preparing wagon	68	9.9
		Selecting goods	248	36.1
		Goods to barrow	150	21.8
		Moving between vans	11	1.6
		Other work	60	8.7
	Not working	No work available	43	6.3
		Waiting for Porter	73	10.6
		Other causes	1	—
	Away from platform		33	4.8
	Total observations		687	100 %
Van Loaders (Checkers)	Working	Reading labels and sheets	382	31.2
		Loading trailers	331	27.0
		Other work	39	3.2
	Not working	No work available	279	22.8
		Other causes	46	3.7
	Away from platform		152	12.4
	Total observations		1 229	100 %

Fig. 8.

which is taken from a study of a goods handling depot, shows how an accurate analysis of the activities of all the staff in one depot or in one section of a depot may be recorded. The value of this information can scarcely be overstated when decisions have to be made on the layout, organisation and manning of such a depot. To have acquired the same knowledge by continuous study of each individual would have been far too expensive and too prolonged.

Activity sampling is in use in connection with both *method study* and *work measurement*. Standard times for tasks can be established just as accurately by sampling as by ordinary time study. Broader movements and patterns of activity are

often more adequately and accurately recorded by *activity sampling* than by direct observation throughout one or two cycles of a process. This is particularly so in the case of receiving, sorting and despatching processes which are found in parcels handling and goods traffic working.

6. WORK STUDY TRAINING.

a) Training Centres and Courses.

Although most administrations have, at the outset, employed industrial consultants to set going their programmes for training in Work Study, there is an increasing tendency for training establishments to be set up to enable administrations to undertake their own training. The German Federal Railways, the Indian Railways, and the Netherlands State Railways have, until now, employed teaching staff from outside their own organisations. Sweden and Ireland send their staff to training establishments outside.

Perhaps the most extensive training programme is that of British Railways where a residential Work Study Training Centre, operated by the British Transport Commission, is used for the training of senior officers and senior staff in the principles of Work Study and associated subjects. This Centre is supported by a Work Study School in each of the six railway Regions. These establishments are collectively capable of providing basic courses of not less than ten weeks' duration for some 200-300 Work Study personnel, as well as appreciation courses for several hundred officers each year. An example of a short course provided by the Work Study Training Centre is given in figure 9. Several administrations have expressed their intention of setting up schools on similar lines.

Canada and Rhodesia have created Training Centres recently, the former intending to develop regional schools as the Work Study applications expand. Germany, Japan and the Netherlands are all planning to train their own Work Study staff. The Norwegian State Railways emphasise the practical nature of Work Study training and indicate that the bulk of their training takes this form.

Many industrial consultants have made a practice of training practitioners with a minimum of classroom work, imparting all the necessary knowledge by means of the practical training of one man « apprenticed » to another. This system normally produces a competent Work Study man, but it has the disadvantages of being slow and expensive and of not creating the consistency of practice that is essential in a large administration. Training Centres can be designed to fill these needs, even though it is extremely difficult to re-create in a laboratory or lecture room a situation which exists in practice. A Work Study laboratory illustrated by the photograph is part of the solution to this problem, but the essential need is for as much practical on site work as possible to be incorporated in the timetable of training courses, and for the course itself to be followed by a long period of guidance in practical work during which the trainee is not allowed to regard himself as trained.

At the Work Study Training Centre of the British Transport Commission this need is met by carefully balanced training. Each separate technique of Work Study, for example *process charting, string diagramming, rating* and *activity sampling* is explained in the lecture room. This is followed by practical demonstration and exercise in the laboratory, followed, in turn, by practical application under guidance on the site of some railway or other industrial activity. Towards the end of the course a limited project is undertaken when the students are free to use any, or all, of the techniques which they have been taught. Their reports are presented to the management concerned and subsequently discussed with them.

In Section 5 of this report some distinction is drawn between *method study* and *work measurement*. This is made largely

British transport commission work study training centre appreciation course for designers and planning officers of new construction

First week D. 16

Day	*9.15-10.45*	*11.00-12.30*	*2.15-3.45*	*4.00-5.30*	*Evening*	*Day*	*9.15-10.45*	*11.00-12.30*	*2.15-3.45*	*4.00-5.30*	*Evening*
Monday	10.00 a.m. introduction	Method study	Method study		Work study films	*Monday*	Work study in B.T.C.	Economics of new construction	Predetermined motion time standards		Variety reduction film
Tuesday	Work measurement		Work measurement		Other methods of recording	*Tuesday*	Work study in offices	Work study estimating & costing	Human relations	Design case study 2	Case study 2
Wednesday	Labour cost control and incentives		Motion economy		Free	*Wednesday*	Case study 3		Work study and design (Visiting lecturer)		Free
Thursday	Case study 1		Case study 1		Case study 1	*Thursday*	Operational research	Ergonomics	Case study 4		Work study films
Friday	Case study 1		Tutorial			*Friday*	Case study 4	B.T.C. future construction	Closing session		

Fig. 9.

Work Study Laboratory.

This Laboratory is used for practical training and development in Work Study techniques. Note the central exhibition in which the cost of typical items of railway equipment are portrayed.

	Canada (C.N.R.)	*Netherlands (N.S.)*	*Norway (N.S.B.)*	*Rhodesia (R.R.)*	*South Africa (S.A.R.)*	*Sweden (S.J.)*	*United Kingdom (B.R.)*	*West Germany (D.B.)*
In training centre								
Lecture room . . .							145	
Practical (Laboratory)							55	
Practical (Site) . .							76	
Total hours			67			120	276	
Total weeks	6	8	2		6		10	7
In practice total weeks . . .		7						
Total training weeks		15		52*				

* Work study students in Rhodesia are expected to pass intermediate examinations of the Institute of Industrial Technicians after one year and the final examination after three years.

Fig. 10.

for training purposes, each of these being composed of a number of techniques. A well balanced training course of, say, ten weeks would provide for three weeks on *method study,* a month on *work measurement* and *labour control* and *incentives,* and the remainder of the time on practical exercises and consideration of broader aspects of Work Study.

The lengths of courses operated by the various administrations which replied to the questionnaire in English differed considerably. Although there can be no doubt that some provide training to a higher standard than others, the differences can probably be explained to a large extent by the way in which the practical training is given. Some courses including practical training as an integral part of the course, while others confine the course to lecture room work, leaving the practical training to be given later in practice. It is on this assumption that the undermentioned brief table in figure 10 is compiled.

These figures appear to be incomplete due to the administrations having given their replies in different forms. To have presented these as comparable figures would have been misleading, for it may well be that the 120 hours and 67 hours for Sweden and Norway respectively are solely lecture room hours and do not include any practical work.

b) Qualifications of Personnel.

From a study of this report as a whole it is clear that applications of the scientific organisation of work cannot be made coldly with no regard for the human understanding which is the essence of good management. Work Study staff, whose contact with the individual is often closer than that of any other, can never afford to ignore this aspect. It is often claimed that the success of Work Study lies only 10 % in the satisfactory use of the techniques and 90 % in common sense and human understanding. There are undoubtedly some who cannot adjust themselves to this approach and whose efforts in Work Study can never be wholly successful.

The Work Study man must have a strong but pleasant personality; his determination and confidence in his work and in the need and opportunity for increased productivity, must be tempered by not only tact but also by a sympathetic understanding of those whose work he has to study. At the same time he must be free from prejudice, sincere, with an observant eye for fact, an analytical mind and the capacity for original thought. Such characteristics are most commonly found in the younger staff who have had at least five years' experience in industry; those who have experience of both direct work and of responsibility being of particular value.

In addition to these personal attributes, satisfactory standards of training are essential. As stated at the foot of figure 10, the Rhodesian Railways train their Work Study staff up to the standards determined by the Institute of Industrial Technicians. No other administration appears to have adopted such an ambitious policy, although several aim at a high standard of proficiency in their staff engaged on work for increasing productivity. The Netherlands Railways have two with University Degrees in the Work Study Section of their Exploitation Department and ten with High School Degrees. In their Workshops the specialists are drawn from the ranks of technicians, several of whom also have High School Degrees.

Over half of the Work Study staff in the Swedish State Railways have served as Engineers or Traffic Apprentices. In Norway these men are drawn from those with higher or lower technical or economic education, from traffic personnel or, in the case of Workshops, from skilled artisans who are given basic education and Work Study training. In South Africa a number of selected officers are employed in the small Work Study Department of that railway. Work Study officers in

Education :				
a) General	Senior matriculation.	Senior matriculation.	Senior matriculation or equivalent.	Senior matriculation or equivalent.
b) Technical or professional	University degree or equivalent work experience.	University degree or equivalent work experience.	Two years university (or equivalent), including railway apprenticeship.	Successful completion of railway apprenticeship.
c) Special	Successful completion of an approved course in the practice of work study, and, preferably, CNR staff training course.	Successful completion of an approved course in the practice of work study and, preferably, CNR staff training course.	Successful completion of an approved course in the practice of work study, preferably supplemented by more specialized courses in some aspect of work study.	Successful completion of the CNR course in the practice of work study.
Experience :				
a) General	Considerable & varied administrative experience at senior management level.	Considerable general administrative experience at middle management level.	Considerable shop or line experience in a supervisory capacity.	Moderate shop or line experience as supervisor.
b) Technical	Considerable experience in the application of work study in the company.	Moderate experience in the application of work study in the company.	Some experience of work study as practiced in the company.	Moderate experience of shop processes and methods.
Job knowledge . . .	Extensive general knowledge of regional organization and activities of operation dept; special training given at CNR work study training centre.	Thorough knowledge of organization and activities of MP & CE dept.; moderate knowledge of regional organization and activities of operation dept; special training given at CNR work study training centre.	Thorough knowledge of organization & activities of MP & CE shops; general knowledge of MP & CE dept. organization and activities; considerable knowledge of work study principles & techniques.	Good knowledge of work performed in railway MP shops. Special training in work study given by CNR.
Administrative abilities	Very capable organizer & administrator. At the introductory stages, the selection training & development of personnel is of utmost importance.	Capable organizer and administrator. Very good ability to select, train and generally develop work study personnel.	Able organizer and administrator. Conscientious in developing subordinates.	Methodical conduct of assigned projects. Detail training of work study technicians.
Special abilities . . .				
Verbal & written communication	Must be able to write well and concisely and express himself simply and clearly.		Must be able to write well and concisely and express himself simply and clearly.	
Personal qualities . .	Must be self-confident, sincere & honest to gain confidence & respect; believe in the importance of his work and exercise tact in gaining the cooperation of work contacts. Must be very mature.	Must be very mature.	Must be self-confident, sincere & honest to gain confidence & respect; believe in the importance of his work and exercise tact in gaining the cooperation of work contacts.	

Fig. 11. — Job Specification. Canadian National Railways.

Rhodesia are expected to be Associate Members of the Institute of Industrial Technicians, as stated above, or of the Institutes of Industrial Administration or Production Engineers, or of the British Institute of Management.

The Canadian National Railways have prepared a comprehensive Job Specification for each of the four grades employed in Work Study in that administration. An extract from this specification, which indicates the qualifications required, is included in this report in figure 11. British Railways draw their Work Study staff from various grades according to requirements — some artisan staff and others professional and technical staff — and generally regard the ten weeks' basic training at a Work Study Centre as the first essential qualification. Although no specific period for subsequent practical training is demanded, the general view is that at least twelve month's practice in Work Study is essential before basic training can be regarded as complete.

c) **Progress.**

The numbers trained in Work Study in all the administrations which replied to the questionnaire in English were but small percentages of the total staff on each railway. The largest numbers were 1 100 on British Railways and 1 000 on the Japanese National Railways. In the case of the latter, 400 were employed in workshops, 500 on stations and depots, and 100 in the offices of the railway. In Norway 220 have been trained, in West Germany 177 have been trained since 1958 and in Sweden 125 out of an intended total of 150. The Indian Railways are at present confining their activities to workshops for which they have trained only 5 so far to operate in their main works at Chitteranjan. London Transport Executive have 22 who have received basic training in Work Study.

The South African Railways and the Rhodesian Railways have trained 36 and 22 respectively but, with every intention of expanding, are unable to say how many will be needed for future development. The Netherlands, on the other hand, with no plans for further expansion, have 33 Work Study staff operating for 25 000 staff in the Exploitation Department and 20 for 2 500 in the workshops. The German Federal Railways intend to train 1.5 % of their total workshop staff. The Norwegian State Railways intend to train 1 % for workshops ond 0.5 % for other departments.

The proportions of Work Study staff to total staff are never constant while such organisations are expanding. When developments are complete, however, the numbers seem to settle donw at about 1 % wherever there is any variety in the work being carried out and to less than 1 % where work is repetitive and not complex. *Work measurement* leading to the calculation of performance indices and incentive payment increases the volume of work for Work Study staff and, in these cases, it is not possible to reduce the percentage without losing control of the labour performance which, as demonstrated in the discussion of Productivity Measurement, is a highly valuable product of Work Study. In extreme cases of non-repetitive jobbing work under such an arrangement a percentage as high as 5 % may have to be employed, although this, fortunately, is rare in the railway industry. It may well be that each administration should budget for a figure of 1 % of its total staff to be fully trained in Work Study.

Most of the replies made brief mention of appreciation courses which are designed to explain to management and staff what Work Study is intended to do, although few statistics were given. The Norwegian State Railways give appreciation courses to 2 % of their supervisors and officers. The German Federal Railways have, since 1958, given such courses to 40 staff representatives. British Railways have given appreciation courses to 5 300 staff, including Members of the British Trans-

port Commission, to almost all General Managers and Senior Officers and to 45 full-time Trades Union Officers.

7. INCENTIVES.

a) Non-Financial Incentives.

In the broadest sense incentives exist in almost all aspects of good management. Any treatment of staff which satisfies the individual acts as an incentive to higher performance. Satisfaction of an employee's sense of self-importance, or of his wish to conform with the community, can be of great value. So also can be the provision of adequate welfare facilities and of congenial surroundings and work places. The creation of a strong spirit of common understanding throughout an enterprise, which is discussed in Section 4 of this report is itself one of the most effective incentives. Many of these factors introduced in isolation might well be of little value as incentives. In the aggregate, however, they can attract from employees a measurably higher performance.

The classic case of a study of the effects of minor changes in working conditions is found in the Hawthorne experiments which were carried out in the United States between 1927 and 1932. Under the direction of Elton Mayo, who was then Professor of Industrial Research at Harvard University, the National Research Council of the United States undertook a series of experiments at the Hawthorne Plant of the Western Electric Company. These were set in motion by similar experiments in 1924 when an attempt was made to discover the effect of different conditions of lighting. It was proved conclusively that productivity was increased more by the interest that was shown in the operators throughout the experiments than by the actual improvements in conditions. Undoubtedly the strongest effect of non-financial incentives upon labour performance is not the positive one of raising productivity, but the negative one of lowering productivity when those non-financial incentives are deficient. A number of attractive features of employment may well raise performance, but one unattractive feature which management appears to ignore can undo the good effects of even the strongest incentives whether non-financial or even financial.

b) Financial Incentives based on Work Study.

The most practical and consistently effective incentives are financial bonus schemes of payment by results. These demand an accurate analysis and measurement of those results. This is commonly provided by schemes of production control, labour control or costing, and is most effective when based on sound *work measurement*. Financial incentives of this kind may, however, be based on a far broader basis and resemble profit sharing schemes which are commonly found in some industries. Such schemes are not generally used by railway administrations due, possibly, to the difficulty in measuring transport service rather than physical output. At the other end of the scale are the precise and often complex schemes based on detailed *work measurement*. These are gaining popularity in those administrations which are committed to bonus payment for one reason or another. Between these two extremes many piecework and tonnage schemes are in existence on railways.

None of the administrations which replied to the questionnaire in English was able to report any system by which its employees had a direct and continued interest in the productivity of the administration as a whole comparable to the profit sharing schemes mentioned above. Many, however, stated that the reductions in working hours over the past few years, in several cases from 48 to 45 hours a week, had been achieved as a result of increased productivity. The Norwegian State Railways made the interesting point that increases in productivity have invariably been the result of staff reductions in

which the lowest paid jobs were abolished : as a result, the average pay has been raised. The Netherlands Railways pointed to the obvious indirect benefit to the employee of increased productivity, in that it enabled the industry to remain in business in competition with other forms of transport. On the Japanese National Railways a form of profit sharing scheme existed; it had no agreed formula, the annual bonus being paid out of the difference between the budget and the accounts and depending upon rate of pay and other factors. A scheme on these lines is operated for Motor Transportation in this administration providing the employee with between 15 % and 20 % of any excess revenue.

In most of the administrations employees in certain sections and departments do have a direct interest in local productivity by means of incentive schemes. These vary enormously; by far the greatest number being reported on the German Federal Railways. With several administrations operating directly proportional piecework schemes, the rises in productivity are invariably proportional to rises in pay. This has been the case in West Germany and Norway. Egypt has achieved a slight increase by means of her points system, which has produced a 28 % increase in productivity for a 25 % increase in wages. Japan has achieved 10-15 % for 10 % increase in wages. India, in the last four years, has increased productivity in its Works at Chitteranjan by more than 50 % for some 25 % increase in wages. British Railways, with two widely adopted systems — piecework and that resulting from Work Study application — have shared the rise in productivity between management, staff and the improvement of the service, with the result that productivity has risen faster than equivalent wages.

This has been most pronounced in the case of the piecework system where the bonus earnings, although directly proportional, are related to a basic rate of pay which is less than half of the present total timework rate. The Work Study applications have given more generously in return for a much closer analysis of the work and the setting up of improved methods and controls which themselves have raised productivity irrespective of manual effort. The effects of these two systems are illustrated by the graphs in figure 12.

Labour disputes in Argentine have prevented any increase in productivity in the administration in that country. The South African Railways state that rises in productivity, although extensive, cannot be pinned down with any certainty as the result of any particular factor. Modernisation, rationalisation, dieselisation, and many other factors have had as much effect on productivity as incentives have done, so that no administration on achieving an overall productivity rise of a particular figure can analyse that rise and its causes with precision. It is possible that deeper studies into productivity analysis and measurement may reveal a means of tackling this problem.

c) Other Financial Incentives.

The questionnaire linked the subject of incentives with that of Work Study in an attempt to discover those administrations which were using Work Study as a means of establishing the standards of performance. The term « Standard Minute Values » was used in this context with the result that only British Railways and the Indian Railways regarded their incentive schemes as falling within these narrower definitions of Work Study. In Argentine, Germany, Japan, Norway, South Africa and Sweden, systems of piecework were in operation, in the Workshops principally, but in some cases in other departments also, in which the standards were issued as piecework times rather than as piecework prices. The processes of establishing these times in Germany and South Africa are equal to the Work Study processes in their science and precision, the

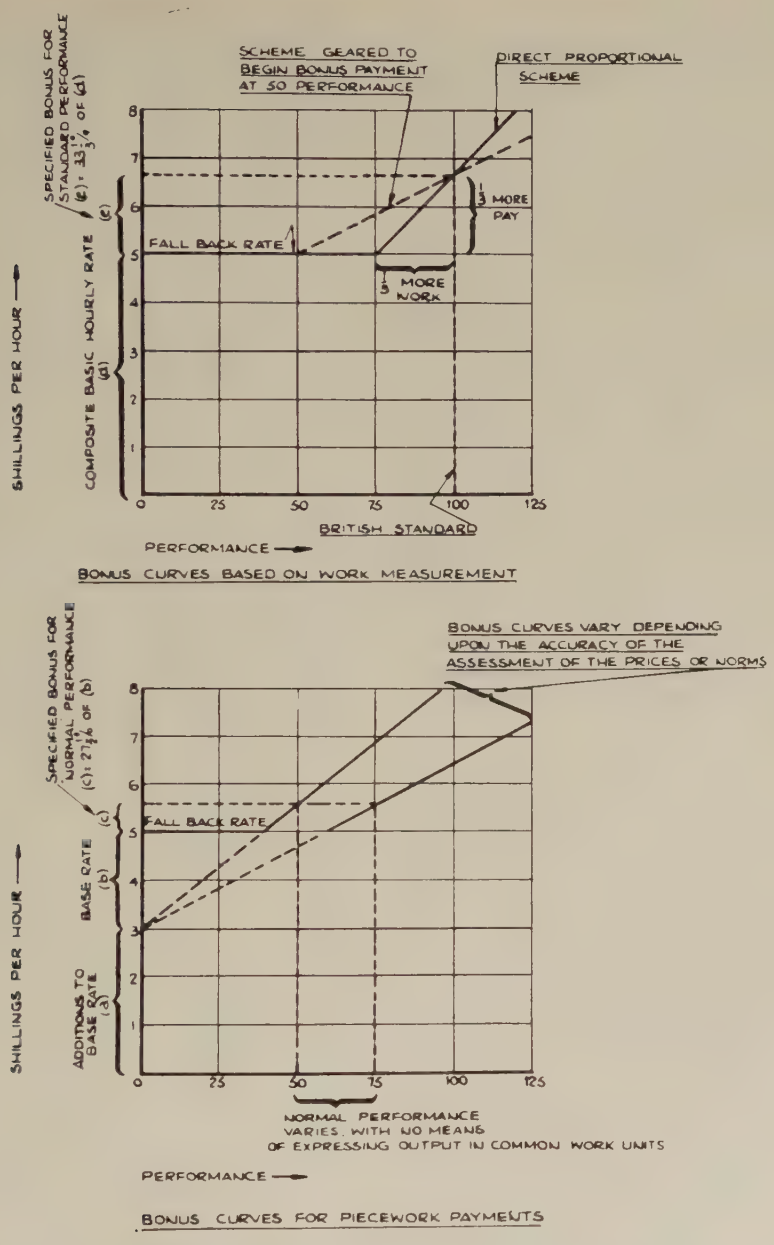

SCHEME GEARED TO BEGIN BONUS PAYMENT AT 50 PERFORMANCE
DIRECT PROPORTIONAL SCHEME
SPECIFIED BONUS FOR STANDARD PERFORMANCE (c) = 33⅓% OF (a)
COMPOSITE BASIC HOURLY RATE (a)
SHILLINGS PER HOUR
FALL BACK RATE
⅓ MORE PAY
⅓ MORE WORK
0 25 50 75 100 125
BRITISH STANDARD
PERFORMANCE
BONUS CURVES BASED ON WORK MEASUREMENT
BONUS CURVES VARY DEPENDING UPON THE ACCURACY OF THE ASSESSMENT OF THE PRICES OR NORMS
SPECIFIED BONUS FOR NORMAL PERFORMANCE (c) = 21¼% OF (b)
ADDITIONS TO BASE RATE (a)
BASE RATE (b)
FALL BACK RATE
NORMAL PERFORMANCE VARIES. WITH NO MEANS OF EXPRESSING OUTPUT IN COMMON WORK UNITS
PERFORMANCE
BONUS CURVES FOR PIECEWORK PAYMENTS

Fig. 12. — British Railways. Bonus curves for piecework payments and for bonus payments based on work measurement.

other administrations adopting varying degrees of accuracy.

The incentive bonus scheme which has become widely adopted on British Railways and which is of the same kind as that at Chitteranjan in India, is based on accurate work measurement. The observed times are adjusted in accordance with the system of effort rating, and allowances for relaxation are added in accordance with accepted practice. Very accurate specifications of the work and the way it is done are prepared. The times are then issued at a specified level of performance in work units. When the work has been completed the performance can be calculated in terms of a scale corresponding to the rating scale. This performance is an ideal productivity index of great value to local management and a straightforward basis for incentive payment. Such a system comes as near as possible to the ideal of increased payment for increased productivity in which the productivity or performance is calculated at the level of operation of the individual worker himself.

It is believed that Work Study techniques have been employed in Russia in recent years in the establishment of « norms » of work, although it is difficult to reconcile this practice with the remarkable excesses of performance that are claimed by individuals in that country. With increasing use of *work measurement* and accurate work specification, it will be interesting to see if standards of performance there settle down within narrower limits. Normally, if the standards have been correctly set, one would not expect to see depot performances regularly exceeding 100.

Although in the final analysis the « norm », the standard time, piecework time or piecework price, is influenced by the bargaining power of the worker and the nationally or locally accepted rates of working, the tendency is apparent in all systems for the increased application of scientific analysis, specification and measurement to lead to a more consistent level of performance. None of the administrations laid any emphasis on the negotiation of times, although on the Norwegian Railways the times were agreed by the Work Study representative of the staff. If this man has the ideals of *work measurement* as much in mind as the interests of the employees, the trend towards consistent performance will be continued.

Where time standards or prices form the basis of an incentive scheme, the bonus paid appears to range between 15 % and 40 % of the normal time rate. Where standards are less accurately set, or less specific, as in quality bonuses and fuel conservation bonuses, the payment is invariably less. In Norway the practice is firmly established by which 22 % is paid for a specified performance attained on work which has been measured by study and only 15 % for the same performance on work which has been estimated. The table in Appendix III lists the schemes negotiated and the percentages paid.

Many administrations spoke of the difficulties of paying bonuses to indirect workers, team workers and maintenance workers. The Norwegian State Railway is having second thoughts on its system of bonus payment to maintenance workers. The Indian Railway offers 80 % of the direct workers' bonus to the indirect workers. In Argentine the indirects have group schemes based on the average of the directs. The South African Railways emphasise the advantages of individual schemes over collective schemes. On British Railways it is the payment under a variety of systems of the indirect workers in the Workshops, where the direct workers are earning piecework rates, which creates the greatest anomalies.

Both on the Canadian National Railways and the Netherlands Railways, standard times for tasks are set for the purpose of planning and control without their forming the basis of incentive payment. The Netherlands are conscious of the problems of individual reward of team workers and are also concerned for the

high standards of safety which are fundamental in the railway industry. In the Mechanical Engineer's Department of the Egyptian Railways, the bonus scheme is based on a system of points equivalent to 25 per man day for standard performance. In South Africa the Road Cartage Drivers are given a fixed monetary grant with a full specification for each day's work, and any time saved on this is paid additionally whilst time lost is ignored. In East Africa bonus payment is less of an incentive than is a reduction in hours. Occasionally, particularly on constructional work, task work is set by this administration so that on completion the worker may go home.

On the German Federal Railways, as is shown in the table, bonuses of relatively small amounts are paid for a great variety of deeds and achievements. The Japanese National Railways makes mention of one or two. On your reporter's own system, rewards are given for similar work and it is imagined that most of the other administrations offer awards of this kind. Such payments may be regarded as falling in a class of their own somewhere between the incentives for increased productivity and rates of pay and payment for suggestions, which latter has already been discussed.

d) The Principles of Financial Incentives.

It is seen that satisfactory performances are achieved by several administrations without the aid of financial incentives. This leads one to question the necessity for the introduction of incentive schemes. The answer lies in the existing level of performance which may have been raised by other processes of good management, including *method study*. If a reliable measurement of work has been made and the performance found to be high without any schemes of payment by results, there can be little justification for introducing the complication and burden of clerical procedures which are an indispensable part of effective incentive schemes. As a guide to the level of performance, the table in figure 13 should be studied in conjunction with the sub-section of this report which deals with *work measurement :*

British Standard Scales of Rating and Labour Performance.

Rating factor	*Interpretation*	*Simple equivalent based on walking speeds*
125	Fast	5 m.p.h.
100	Brisk « Standard » (or incentive speed)	4 m.p.h.
75	Normal	3 m.p.h.
50	Slow	2 m.p.h.
25	Very slow	1 m.p.h.
0	Standstill	

Fig. 13.

The speed of work generally associated with work carried out under effective incentive conditions is the « Standard » brisk speed of 100. This the worker can maintain throughout his working day, provided that he takes advantage of all reasonable rest periods, and allowances such as those provided by the *relaxation allowance* which is incorporated in *standard times.*

Where no particular incentive exists either positive or negative, the normal speed of work is generally found to be less than 75. Poor conditions or disinterested management can easily depress this performance to 50 which is a level commonly found in uncontrolled labour forces. Lower performances are, as a rule, found only in isolated cases or for short periods of time.

Higher performances than « Standard » are not uncommon, particularly where the effective working day is short, as for example in the case illustrated in Appendix I. It is less usual, however, for performances above « Standard » to be maintained over the whole working day. The effect of performance upon productivity is clearly revealed by Appendix I in which it is shown that method improvements, to which this example lends itself, removes lost time, providing more time for productive work. Changes in performance make directly proportional changes in the productivity of that ultimate working time.

A conscious and objective application of the non-financial incentives of good working conditions and interested management may, in isolated cases, raise performance to a figure approaching « Standard » or above. More generally, in a large organisation a performance of about 80 is as much as can be expected from such efforts. An example of this is found in Canadian National Railways. If performances are already of the order of 80 or more, the stronger incentive of bonus payment by results is not generally justified. Occasionally, the application of such schemes to an entire department where the average is low may involve unprofitable payments in certain cases merely for the sake of consistency and fairness to employees.

Bonus payments related to productivity appear in two distinct forms which correspond very closely to the two extreme approaches to productivity measurement. At the one end of the scale bonuses based on the productivity of an administration as a whole are generally small in relation to the worker's total earnings. They are commonly of the order of 1 % to 5 % and are accepted as part of the normal wage. They can be of no value as incentives but are of some use as tangible indications to staff of the well being of their industry. They are perhaps best regarded as Interest Bonuses.

At the other end of the scale systems of payment of direct workers by results often involve accurate and continuous measurement of work and include additional payments of up to 50 % of the worker's total earnings. They are undoubtedly powerful incentives. When calculated and paid to individuals, notified perhaps daily and paid each week, the closeness of the bonus to the work is of marked importance. Where group payments have to be made or where the interval between the work and the payment is increased, the incentive effect falls off. This falling off may, in some cases, be countered by paying larger bonuses and it is interesting to consider this approach in the light of the very large bonuses which are given to groups of successful workers in the Soviet Union.

High bonuses of the order of 40 % and 50 % and more cannot as a rule be paid for improvements in productivity without threatening the financial soundness of the scheme. In a typical administration there may be some sections where economies are found to be great, but there will be sections where such large bonuses will cost more than the savings produced by the rise in productivity. It is a mistake to relate bonuses directly to savings for such a policy puts a premium on ineffi-

ciency. Even where staff are guaranteed only a fraction of the savings those sections which are least efficient will ultimately earn the greatest bonuses. It is essential to relate bonuses to a « Standard » performance such as that established by *work measurement* even if this means paying bonuses to one or two who are already working at a bonus performance.

The payment of bonuses to supervisors, even when suitable factors may be found, can itself create problems. It is often easy to construct a system of such payment for the first line of supervisors who come into contact with those earning bonuses. Indeed, for this very reason incentives for supervisors are often considered desirable. At higher levels the

Figure 14

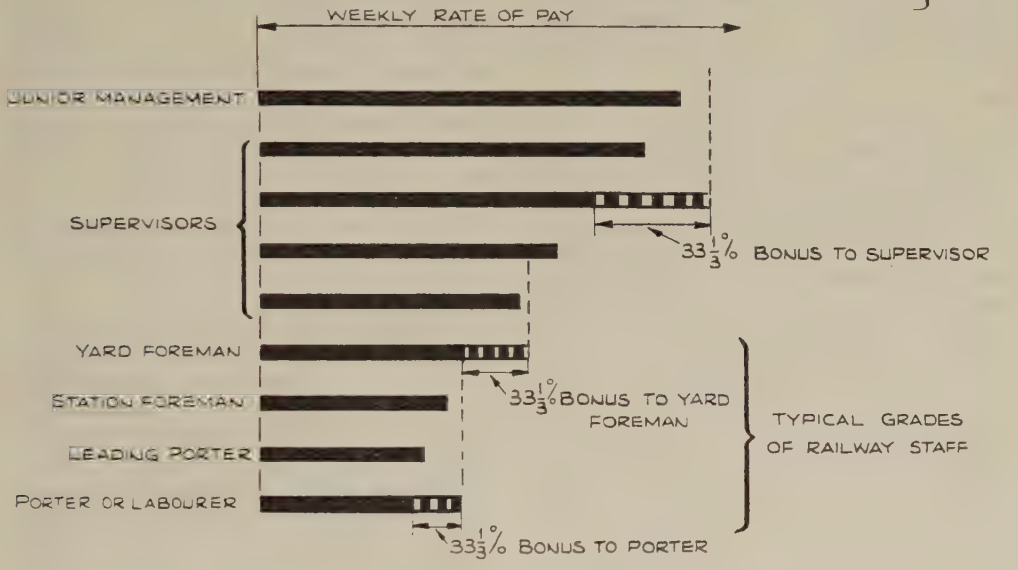


Fig. 14. — Diagram to illustrate the effect of bonuses of 33 1/3 % upon wage and salary differentials.

Where the work content cannot be accurately measured, incentive schemes often have to be based upon a number of factors. The performance of direct workers may be one of these; others may include quality of work, absence of failures or complaints, good timekeeping, utilisation of equipment and so on. Such schemes are commonly referred to as multi-factor schemes. Frequently bonus payments based on such calculations are smaller than those based on directly measured work. In some instances supervisors are included in incentive payment by means of multi-factor schemes.

payment of bonuses can well lead to a change of attitude amongst supervisors who previously enjoyed a sense of being part of management. Not only will management see the supervisors becoming more closely associated with the operators but, moreover, management will be faced with problems arising from supervisors earning more than those to whom they are responsible.

This upseting of differentials by the payment of bonus can present problems with no ready solution. Normally, incremental advances on the promotional ladder are of the order of 10 % to 20 %.

It has been stated already that to be effective the bonuses must be of the order of 30 % or more of normal pay. For this reason it is wise, when considering the introduction of bonus schemes, to plot all grades of staff in descending order of weekly earnings who are likely to be concerned in order to see if there are any differentials which are closed by payments to lower grades which cannot be re-created by similar payments to higher grades. Diagram serves to illustrate this point.

8. CONCLUSIONS.

It is evident, having regard to the wealth of information which has been provided for this paper by a large number of administrations, that there is an unlimited number of steps which may be taken to promote high productivity on railways. It is equally evident that the scope for Work Study is so great that its value can scarcely be over emphasised.

The measurement of productivity is an essential key to the efficiency of an administration. It is of the greatest value and is most widely practised in two distinct forms. First, in the form of broad ratios of input to output in terms of ton miles and passenger miles per employee, wagon, coach or locomotive. Second, in the form of accurate measurements of the details of input and output in the carrying out of work by one group of men, workshop or depot.

In the first case, that is in the use of broad ratios, monetary factors, or even coefficients derived from financial sources, may be used with extreme caution. The construction of complex formulae which defy ready understanding may well be of less value to management, and certainly of no value to staff, when compared with broad physical ratios whose disadvantages are certainly large but which, at the same time, are clearly understood.

In the second case, that is where detailed measurements are made, it is essential that the most critical analysis is applied. It is only from such analysis of activity that any accurate meaning can be attached to productivity measurement. Attempts to compromise and produce a measure of productivity between the broadest and most understandable ratios, on the one hand, and the accurate detailed measurements on the other, will suffer from both disadvantages without serving any useful purpose : it will be complicated without being accurate.

In practising such detailed measurement, railway administrations should think less in terms of voluminous quarterly or annual statistics and should concentrate on deriving as far as possible accurate data gathered from specific studies of particular fields of activity. The result of really thorough investigations into the productivity of, for example, the marshalling yards on one administration, should be made available where appropriate for others to study.

From the extent to which railway administrations have already set up sections within their organisations with the specific purpose of raising productivity, it is clear that railways all over the world generally consider such sections to be of considerable value. The organisation of these sections varies, but the advantages appear to lie with those which combine in one central office the administration of all functions specifically directed towards higher productivity, decentralizing at the same time, through the existing organisation, the executive responsibility for putting these various functions into practice.

Few railway administrations possess joint bodies or any other means whereby the full meaning of productivity and its implications can be discussed freely and understood by staff and management together. There is much to be gained from increasing common understanding of productivity. This might be achieved through formalised training.

It is common knowledge that the relationships between staff and management are always changing and that the trend is constantly towards increased humanity of behaviour. These changes culminate in ever growing formality in machineries of

negotiation, procedures for joint consultation, rights and guarantees. The end of these developments is nowhere in sight. This poses a number of questions such as: « Where will they end? cannot the end be anticipated and hastened and thereby the increased productivity to which it contributes be realised earlier? what are the basic principles behind all the formal agreements? cannot these be recognised and practised, thereby avoiding the laborious working out of procedures and rules? ».

Complete answers to these questions are not to be found in this report, nor in the replies upon which it is mainly based. Nevertheless, some lessons may be learnt: the creation of formal machinery to undertake tasks which are better performed informally will, ultimately, defeat its own object. The stultifying of relationships which increased formality brings about will necessitate either an additional medium to serve the original purpose, or else a rejuvenation of the existing machinery based on fundamental rethinking.

If agreements and guarantees are to serve their purpose most effectively, they must be the outward signs of a prevailing spirit of human understanding and not the sole unsatisfying product of prolonged bargaining. The features for negotiation between staff and management are unlimited. The conclusion of a written guarantee on any one of these often contains a suggestion that there has been a lack of confidence. Without a wide measure of common understanding, each agreement will lead all too quickly to disagreement and so, in turn, to the need for further agreement.

Communications between staff and management must be considered according to the direction in which information can flow and the distance over which it has to travel. Consultation provides a two-way traffic of great value. The closer this is to the man who is concerned, the more effective this will be. Training provides a flow of information which is largely one way. The contact is close but one-sided. Literature, posters, films and notices provide a completely one-way flow of information. To counterbalance this prevailing tendency to communicate from management to staff and not from staff to management, the suggestion scheme is of great value. It serves in this way not only as a means of gathering useful ideas, but as an outlet for thoughts which so often become suppressed in a large railway administration.

There is no doubt that the pursuit of relationships between management and staff in an atmosphere of mutual understanding supported by genuine, informal and close discussion, and by adequate communication of information and ideas, will promote that co-operation which leads to improved productivity.

Upon this sound and healthy basis, individual performance will rise automatically. It is well-known, however, that, although it is natural for a contented worker to work well, it is not natural for him to discover and use the shortest and most efficient method when work patterns are constantly changing. With the increasing complexity of work, particularly in the large organisations, crafts and other occupations have no time to develop or adapt themselves to new processes and new conditions. Waste and inefficiency are common.

Work Study can certainly be said to be of the greatest help in overcoming this problem. Whether it is called Work Study or anything else, the close analytical and critical study of any work is the essential practice of management which can no longer be treated lightly. In the case studies which are attached to this report, there is conclusive evidence that there is great scope for Work Study on railways: it is indeed the most powerful single positive means of raising their productivity.

A high proportion of the tasks involved in the running of a railway do not readily lend themselves to automation but must, for many years to come, require the personal attention of individual workers. This applies to a very great extent in technical departments which are mainly concerned with maintenance work. For this reason,

the labour content of railway operation is proportionally high and cannot help but benefit as much as any industry from detailed study of the work involved.

Work Study has added advantages in that :

i) it is sufficiently close to the work for it to be understood by the individual who is doing that work;

ii) it is practised openly in full view of that individual with no concealed recording or hidden investigation;

iii) it provides thereby a further channel of communication from staff to management;

iv) it points to economies which do not necessarily involve the investment of large sums of capital;

v) it is applicable to all aspects of work, including both technical and clerical office work and the design of new installations at the planning stage before any capital is invested.

The practice of Work Study necessitates particular attention to training and qualifications of Work Study staff, and to organised dissemination of the meaning and implications of Work Study and its ever advancing techniques to all employees. Industrial Consultants may be of some value at the outset of such developments in an administration. There is great advantage, however, in the creation of Work Study Training Centres operated by internal staff.

The qualifications of Work Study staff should be high, including a full course of 10 weeks or more under close supervision followed by at least two years in positions of increasing responsibility. Examinations and the membership of appropriate professional societies are an added advantage in raising the standard of Work Study practice. In addition to a mastery of techniques and their applications, the Work Study Officer must possess those personal qualities which will enable him to make a success of a job in which he is in daily contact with the individual worker. Whatever his subsequent promotion may be, his knowledge of Work Study and its application will make him a better candidate than otherwise would have been the case.

Beyond the practice of general good management and the existence of adequate means of communication between management and staff, it is possible to raise productivity by direct attention to particular features of employment and working conditions. The effect of non-financial incentives can be very marked. The negative effect of poor conditions is well known.

Financial incentives have been paid to some classes of railway employees for many years. Piecework schemes are often of long standing, particularly in workshops. The more recent application of Work Study and the practice of *work measurement* have made it possible to measure the actual performance of staff in almost all categories. This has led, in many cases, to the expansion of incentive bonus payments. The two are not inseparable, indeed, extensive Work Study on a basis of sound relationships which have already raised individual performance may be more effectively pursued without the complications of incentive payment.

Where, however, performances are low, in any field of railway activity, there is no doubt that the payment of substantial bonuses of the order of 25 % of earnings or more will be of great value. Even where the work is not directly measurable, as, for example, in inspection and supervision, bonus payments by results based on an evaluation of a small number of relevant factors may contribute to higher productivity.

Bonus schemes based on broad indices of railway productivity similar to the profit sharing schemes of other industries are rare. Such schemes, which pay small bonuses on a very wide group basis, are not effective incentives but are useful as interest bonuses which can possess some psychological value.

With regard to incentive schemes generally, there is considerable evidence to show that the greatest value springs from those

designed for individual payment by results rather than group bonuses. Here, too, Work Study will provide the most satisfactory means of determining performance and setting reliable standards.

Summing up in a few words the answer which this report gives to the question before the Permanent Commission, it can be said that there is much which can be done to raise the productivity of railways. Much has been done already, but this is but a beginning. Only a conscious and persistent pursuit of higher productivity, following the psychology and technique suggested by this report, will enable the railways to exploit their significant technical advances to the full by matching their organisational efficiency to that of their younger competitors. These latter are relatively free of practices not suited to present day conditions and threaten to offer more attractive and more efficient transport services.

This is a challenge which cannot be neglected.

APPENDICES

PRODUCTIVITY OF LABOUR. ILLUSTRATION OF EXAMPLE OF 7 MEN WORKING TOGETHER.

Notes supporting Appendix I.

Class of Work Involved.

The example refers to a gang of 7 men engaged on repair work of a railway bridge abutment wall.

The first man is the Chargehand who spends much of his time supervising the others and planning their work.

The second man is using a pneumatic drill to break out stonework at the top of the wall between tracks.

The third man is assisting him by shovelling the broken stone into baskets.

The fourth man is carrying the basket away and tipping the rubble.

The fifth man is engaged on other work preparing shuttering for new stonework.

The sixth man is looking out for trains to protect his colleagues.

The seventh man is attending to the compressor, cleaning the hut, making tea, and to other miscellaneous duties.

Assumptions.

It is assumed that allowances are made in this example for unproductive time which the operators cannot avoid :—

Unoccupied Time Allowances (U.T.A.) :

1. If operators (2) and (3) are working in a confined space and (3) can only work when (2) stands clear, the net output of the two men is almost halved. For control purposes an allowance of 75 % is assumed.
2. If the work performed by operator (4) takes less time than the work of (2) and (3) then (4) will incur unproductive waiting time. Here an allowance of 25 % is assumed.
3. Trains passing over the bridge will delay the work. For this an allowance of 10 % is assumed in this example.

Chargehand's Supervision Allowance :

The Chargehand does productive work when he can but he must also spend time supervising the work of the rest of the gang. For this an allowance of 25 % is assumed.

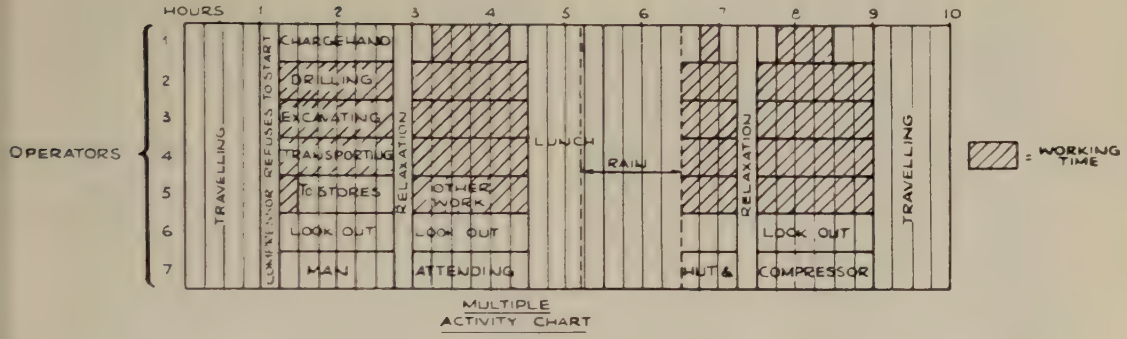
All these allowances are calculated as percentages and are additional to the actual work performed. In view of the short periods during which operators are actually working, it is assumed that they maintain the relative high performance of 120 during these periods.

Calculations.

Daily totals not included in control data	Supervision 3 ¼ hours Tea breaks 3 ½ hours Attendant 5 ¼ hours
Time actually lost by operators (2) and (3) working in turns is less than 5 ¼ hours because they require some rest allowance . .	Time lost (say) 3 hours
Similarly time lost by operator (4)	(say) 1 hour
Total unproductive time from control sheet	29 ¼ hours
Total actual unproductive time (excluding train interruptions) . .	45 ¼ hours
Net working time = 63 — 45 ¼ = ...	17 ¾ hours
Time lost by train interruptions = $17\frac{3}{4} \times \frac{1}{10}$	1 ¾ hours
Unproductive time including train interruptions	47 hours
Actual productive time = 63 — 47 = 16 hours	
Actual work produced = 16 × 120 % = 19 ¼ hours	
(2) and (3) as a team produce $(10\frac{1}{2} - 3) \times 120\ \% \times \frac{9}{10} =$.	8 hours of work
(4) produces $(5\frac{1}{4} - 1) \times 120\ \% \times \frac{9}{10} =$	4 ½ hours of work
(1) produces $2 \times 120\ \% \times 120\ \% \frac{9}{10} =$	2 ¼ hours of work
(5) produces $4 \times 120\ \% \times \frac{9}{10} =$	4 ½ hours of work
Total number of man hours	19 ¼ hours of work
U.T.A. 1 = 8 hours × 75 % = ...	6
U.T.A. 2 = 4½ hours × 25 % = ...	1
U.T.A. 3 = 19¼ hours × 10 % = ...	2
Supervision Allowance = 19 ¼ × 25 % = ...	5
Operator Performance = $\frac{\text{Total Output}}{\text{Net Working Input}} =$	$\frac{33\frac{1}{4}}{33\frac{3}{4}} = 99$
Effective Performance = $\frac{\text{Net Working Output}}{\text{Total Input}} =$	$\frac{19\frac{1}{4}}{63} = 31$

N. B. — Your reporter is aware that the allowances given do not necessarily correspond to the hours lost, the method of calculation adopted being one commonly used in connection with labour control schemes. Any apparent error is negligible in practice where rest allowances are offset by the unproductive time which is incurred.

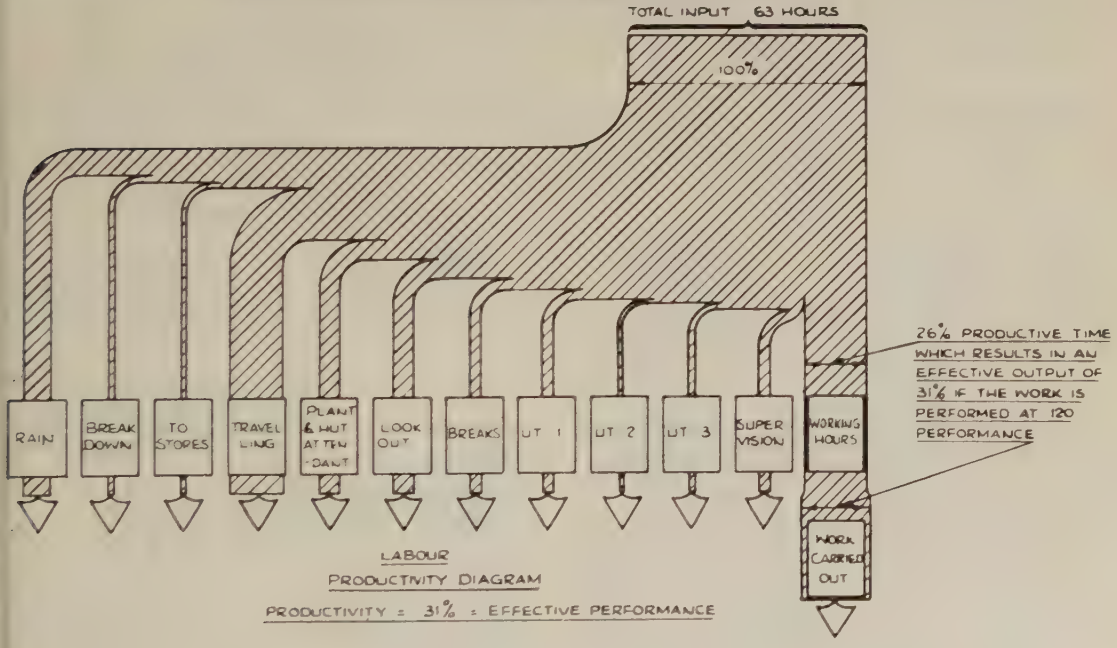
APPENDIX I.



MULTIPLE ACTIVITY CHART

INPUT (HOURS)								OUTPUT (HOURS)					PERFORMANCE	
UNPRODUCTIVE TIME						NET WORKING	TOTAL	NET WORK	ALLOWANCES			TOTAL	OPERATORS	EFFECTIVE
RAIN	BREAK DOWN	TO STORES	TRAVELLING	LOOK OUT	TOTAL				UTA 1	UTA 2	UTA 3	SUPERVISION		
7	$1\frac{3}{4}$	$1\frac{1}{4}$	14	$5\frac{1}{4}$	$29\frac{1}{4}$	$33\frac{3}{4}$	63	$19\frac{1}{4}$	6	1	2	5	$33\frac{1}{4}$	99	31

LABOUR CONTROL DATA
(SEE ACCOMPANYING NOTES FOR DETAILS OF CALCULATIONS)



LABOUR PRODUCTIVITY DIAGRAM

PRODUCTIVITY = 31% = EFFECTIVE PERFORMANCE

Productivity Measurement. Illustration of the productivity of labour.

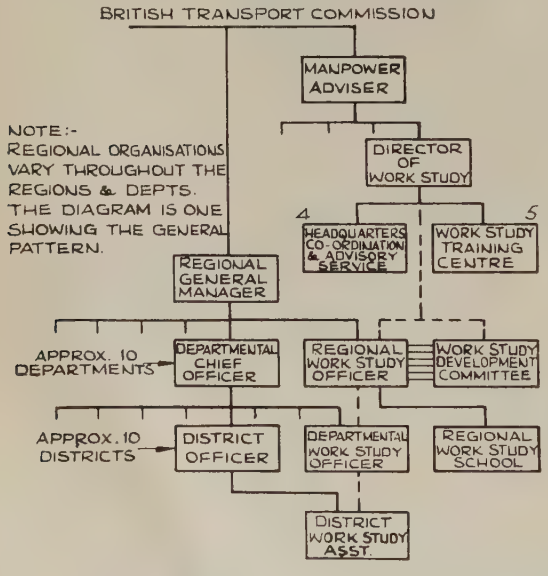
APPENDIX II.

British Railways.

At the Headquarters of the British Transport Commission is a Division consisting of 10 trained and experienced Work Study personnel who give training in Work Study at the Commission's Training Centre, who act as consultants in forming a central advisory body on Work Study, and who co-ordinate the development of Work Study throughout the Railway Regions as well as the other Divisions of the Commission's activities.

On each of the six Regions there is a Regional Work Study Officer who acts as an adviser to the General Manager and who co-ordinates Work Study throughout his own Region. In each department of the Region there is a Departmental Work Study Officer who undertakes the development of Work Study and the carrying out of studies in his department. In some departments this pattern is repeated at District level.

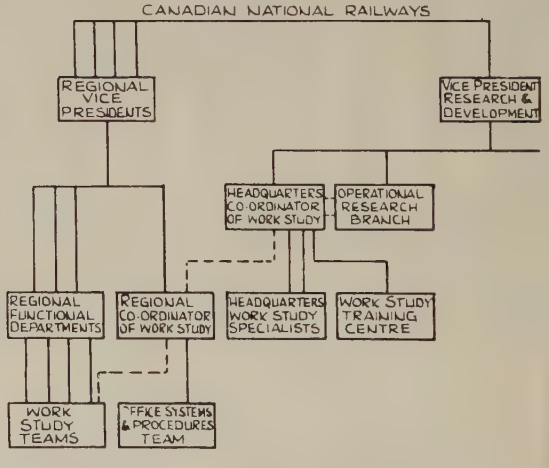
This organisation is already well developed, appointments having been made in all major departments. Some inconsistency does exist in that in one or two Divisions Work Study in offices is undertaken by separate Organisation and Methods Offices. Expansion of Operational Research is taking place and, with many more staff being trained for Work Study, some rationalisation of the organisation for increasing productivity is to be expected. This will be influenced, moreover, by changes which are being made in the structure of the management organisation itself.



Canadian National Railways.

Work Study on the Canadian National Railways is carried out by teams operating in the various departments of the administration. At Regional level these teams are co-ordinated by a Regional Co-ordinator of Work Study who is concerned also with the technical aspects of the Regional Work Study programme. Directly under his control is a team which deals with Office Systems and Procedures. The Regional Co-ordinator is responsible to the Regional Vice President who carries the full responsibility for the successful implementation of the Work Study programme on his Region.

At Headquarters the Regional activities are co-ordinated by a Headquarters Co-ordinator of Work Study. This Officer also has administrative responsibility for a group of specialists who deal with such aspects as Materials Handling and Office Methods. His organisation is located in the department of the Vice President for Research and Development, so that full use can be made by the Work Study staff of the other research and development experience and facilities. In particular, the



Note. — The figures adjacent to the blocks indicate the approximate numbers of staff in the section.

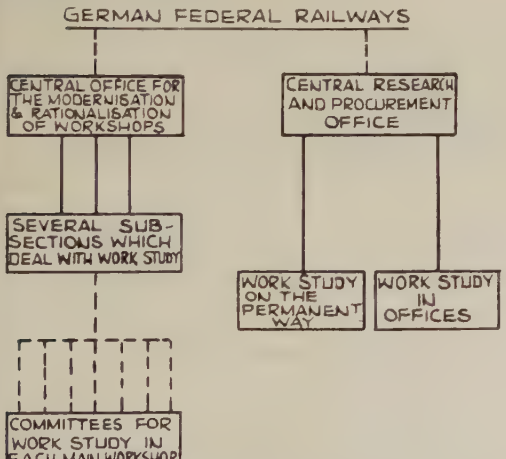
Operational Research Branch works in close collaboration with the Headquarters Co-ordinator.

German Federal Railways.

There is no special organisation for promoting Work Study in this administration.

Each Railway Works has its own Committee for Work Study, composed of the Works Manager and from five to twelve men experienced in Work Study. In addition, there are several departments concerned with Work Study at the Central Office for the Modernisation and Rationalisation of Workshops. These departments are in the charge of a Senior Engineer who has one to four Engineers working under him. They guide and co-ordinate Work Study, assign certain problems to special committees and arrange for the assistance of other Research Officers from inside and outside the administration. Work Study on the permanent way, with particular attention being paid to the most efficient application of permanent way plant and equipment, is in the hands of the Central Research and Procurement Office which also has a special department dealing with improvements in the processing of office work and in the use of modern business machines.

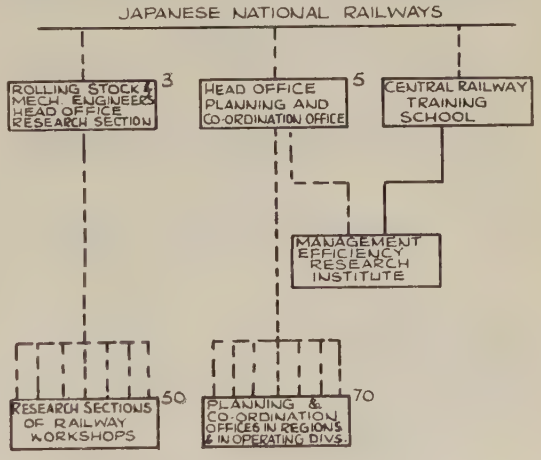
These offices are also concerned with all questions of productivity and give advice and assistance to other departments in their productivity problems.


GERMAN FEDERAL RAILWAYS
CENTRAL OFFICE FOR THE MODERNISATION & RATIONALISATION OF WORKSHOPS
CENTRAL RESEARCH AND PROCUREMENT OFFICE
SEVERAL SUB-SECTIONS WHICH DEAL WITH WORK STUDY
WORK STUDY ON THE PERMANENT WAY
WORK STUDY IN OFFICES
COMMITTEES FOR WORK STUDY IN EACH MAIN WORKSHOP

Japanese National Railways.

Work Study for the Railway Workshops in Japan is undertaken by the Research Sections of the Railway Workshops, all of which come under the supervision of the Rolling Stock and Mechanical Engineering Department of the Head Office. These sections have applied Work Study techniques to the transport and production activities of the Workshops.

Work Study for other than Workshops is carried out by two sections; first, the Planning and Co-ordination Offices at Head Office, and in the Regions and Operating Divisions, for studies into clerical work, station and depot working and other activities. The Planning and Co-ordination Office plans the staffing of the President's Head Office, and of various departments, establishing annual programmes and long-range plans, it analyses the organisation and operation of the business and formulates plans for rationalisation using Work Study, Operational Research and other techniques; second, the Management Efficiency Research Institute is responsible for research on the administration of management, including Work Study, on employee training systems, and on the prevention of accidents and fatigue.


JAPANESE NATIONAL RAILWAYS
ROLLING STOCK & MECH. ENGINEERS HEAD OFFICE RESEARCH SECTION
3
HEAD OFFICE PLANNING AND CO-ORDINATION OFFICE
5
CENTRAL RAILWAY TRAINING SCHOOL
MANAGEMENT EFFICIENCY RESEARCH INSTITUTE
RESEARCH SECTIONS OF RAILWAY WORKSHOPS
50
PLANNING & CO-ORDINATION OFFICES IN REGIONS & IN OPERATING DIVS.
70

Netherlands State Railways.

This administration has no central organisation for productivity, nor does it have any departments at a lower level which are solely devoted to Work Study. In its major depart-

Note. — The figures adjacent to the blocks indicate the approximate numbers of staff in the section.

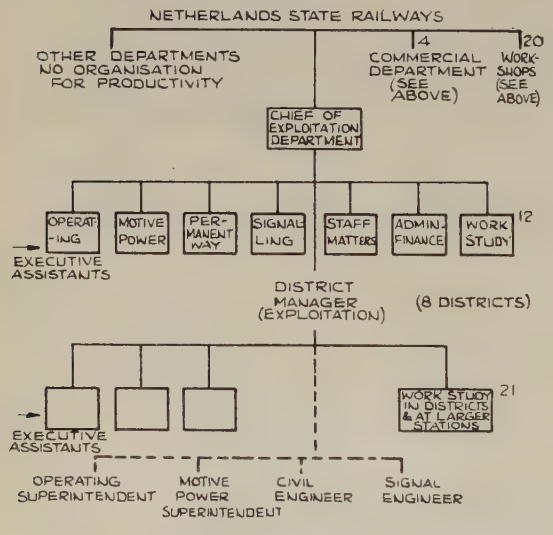
ments there are sections whose principal aim is to raise productivity.

In the Exploitation Department (Operating, Motive Power, Civil Engineering and Signalling) there is a Work Study and Staff Organisation Section, whose function is advisory and includes the use of outside consultants and the organisation of training. This section has proved its value and is to be expanded.

In the Commercial Department, there is a small section engaged on administrative routing, job analysis and task setting.

The Main Workshops each have production planning and control offices which combine the function of labour management with those of production management supported by the techniques of Work Study.

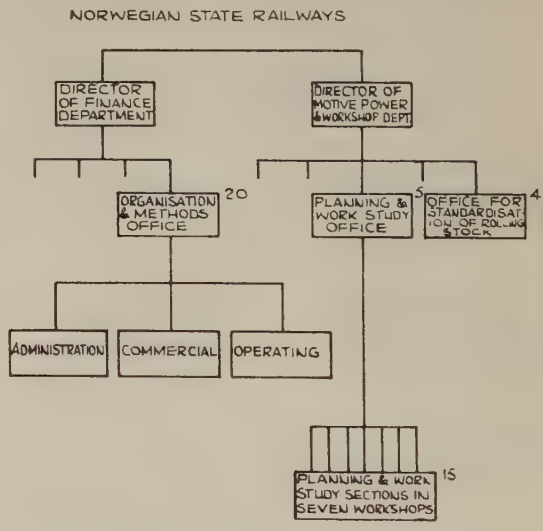
In other departments there is no section specially devoted to raising productivity, this being one of the functions of the chiefs of departments. No expansion of the sections described in the Workshops and Commercial Departments is envisaged.



Norwegian State Railways.

The organisation for raising the productivity of the Norwegian Railways appears in two main branches. An Organisation & Methods Office in the Department of the Director of Finance makes investigations and carries out work studies on technical, economic and administrative questions within the administrative, commercial and operating fields. A separate organisation exists in the Motive Power and Workshops Department where planning and Work Study Offices exist at Head Office and at each Workshop throughout the system. These offices undertake Work Studies and are responsible for the planning of an efficient and economical maintenance of the rolling stock. Another office in this department is responsible for the standardisation and codification of rolling stock constructions, materials and spare parts.

All these offices act in an advisory capacity. The two main branches have had almost parallel development, both using the techniques of Work Study. One section of the Organisation & Methods Office deals with Work Study in offices. There is no immediate expansion intended but it is planned to decentralize the Organisation & Methods Office into smaller offices in various Railway Regions.



South African Railways.

The management of the South African Railways is concerned at all levels with questions of productivity and is assisted by a Work Study Sub-Section established as a part of the

Note. — The figures adjacent to the blocks indicate the approximate numbers of staff in the section.

Financial & Planning Section of the General Manager's Office at Railway Headquarters, Johannesburg. There is no limit to the activities of the Work Study Officers in this subsection, but they have not yet carried out work studies in the Engineering Departments where Production Engineers, some of whom have had Work Study training, attend to works productivity matters. Because of an existing bonus scheme and due to the small numbers of Work Study staff at present, Work Study has not been extended to the artisan, semi-skilled and unskilled grades in the Railway Workshops.

An expansion of the Work Study organisation is visualised and training is proceeding to this end.

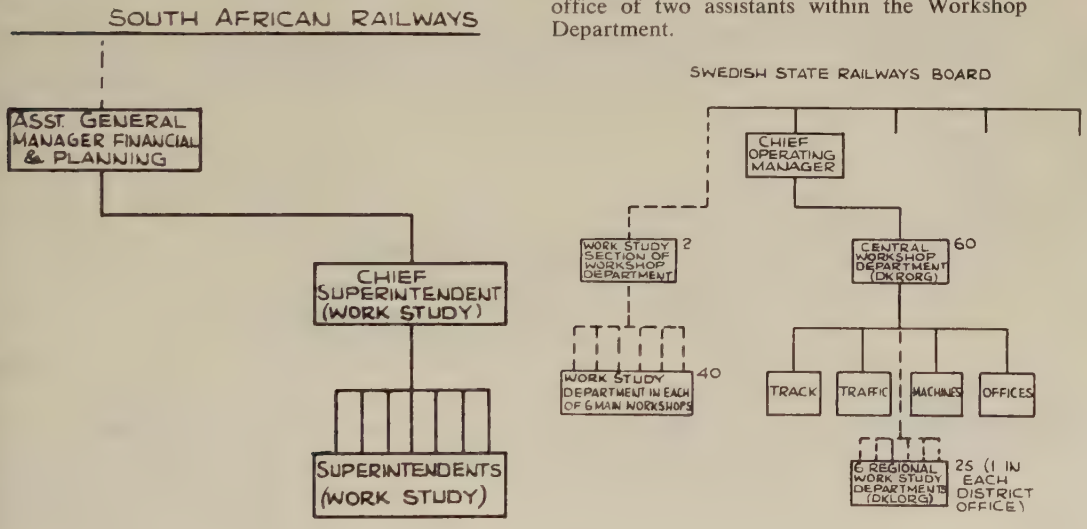
The Work Study Officers usually work in teams of two or more with others of lower rank, temporarily detached from normal duties and given brief courses of training designed to cover the specific needs of the investigation in hand, under their direction. Assistance is obtained from statisticians and from trained office mechanisation and materials handling officers where necessary. Owing to their personal attributes, the Work Study Officers occasionally carry out investigations and committee work not directly connected with productivity.

Swedish State Railways.

The Swedish State Railways have a number of sections for the rationalisation of activities whose final object is the raising of productivity. In addition, Work Study organisations exist in an advisory capacity in the operating departments and in the Workshops.

The Central Work Study Office is a section of the Chief Operating Manager's Department with six District Work Study Offices under the control of the District Managers. The central office concentrates on the specialist functions of research and development in various directions whilst the District Offices deal with local problems connected with planning and with following up measures for rationalisation.

The six main works each possess separate regional Work Study sections which are placed under the control of the Works Managers. These offices are co-ordinated by a central office of two assistants within the Workshop Department.



Note. — The figures adjacent to the blocks indicate the approximate numbers of staff in the section.

Table of work study pra

	British Railways	*Canadian National Railway*
Date commenced work study . .	Isolated depots only 1946. General start in 1953.	« Basic principles since 1930 Intensive use since 1956. Accounts dept. 1953.
Descriptions of work which has been studied	Permanent way, building and signalling maintenance, renewal and new works. Station working, yard working. Stores, motive power maintenance. Carriage cleaning. Design of new installations. Office work.	Mechanical department. Accounts department.
Techniques which are used regularly	Process charts, flow diagrams, string diagrams, activity charts. Time study, production study, activity sampling.	Process charts, flow diagra activity charts. Activity sampling, producti study. Very little time stu
System of rating and rating scale	Effort rating 75 - 100. Standard = 100. (A few sections use 60 - 80 scale at the moment.)	Standard = 100. Daywork rate = 85.
Relaxation allowances	Allowances take into account all relevant factors with an average of 10 % - 15 % with a basic of 8 % and special cases up to 50 %.	Normally 15 % but varies w the job.
Extent of incentive schemes based on work measurement to work study standards	Incentives extended to all work studied as listed above except to train working — 33 1/3 % bonus paid for standard performance on measured work. Normally paid weekly. Basically individual schemes, small group schemes common.	None.
Piecework schemes based on agreed times or prices	Piecework is in operation in most main workshops, rates being published as prices. Bonuses average 35 %.	None.
Other financial incentive schemes	Tonnage schemes are in operation at many freight handling depots.	None.

railway administration. APPENDIX III.

German Federal Railways	*Indian Railways*	*Irish Transport Company*	*Japanese National Railways*
1928-1930 Renewed development 1958.	1951 Chitteranjan only.	1957 Inchicore only.	1925 (interval 1940-1950). Stations and depots 1946.
Maintenance of rolling stock. Maintenance of permanent way.	Workshops — greatest advance in machine shops.	Workshops. Road motor. Stores.	Office work analysis station and depot working. Transport. Production.
Process charts, flow diagrams, time study.. Work descriptions. Material diagrams. Shop layout. Time schedules. Efficiency calculations. Memo motion (on transportation only).	Process charts, flow diagrams. Time study. Production study.	Process charts, flow diagrams, string diagrams. Time study. Activity sampling.	Flow diagram, activity charts (station work diagrams). Time study.
Only difference between « time rate » and « performance rate ». No rating used.	60 - 80 Standard = 80	100 - 133 Standard = 133	None.
Relaxation allowances based on experience and on data issued by the Max Planck Institute. It is sometimes ignored however.	0 to 25 % of time is for relaxation.	Average of 15 %.	Work relaxation 3 - 5 %. Personal needs 2 - 5 %. Fatigue: special over 30 %. heavy : 30 %. medium : 20 %. light : 10 %. special : 0-5 %.
—	At Chitteranjan only. Where 33 1/3 % is paid to direct workers for standard performance and about 27 % for indirect workers. 75 % of staff are included.	None.	—
Piecework is in operation in motive power depots, in main workshops and for 10 % of permanent way staff, the rates being published as times. Bonuses average between 20-28 %.	—	None.	70 % of workshop staff are on piecework.
Many schemes such as : Shunters - quality - 2-8 % bonus Coal consumption : 1-1 · 5 % bonus Hollerith cards: 20-25 % bonus Tickets sold in trains: 1 % bonus	—	None.	A number of group bonus schemes in which employees receive about 20 % of profits or savings.

Table of work study pra

	London Transport Executive	*Netherlands Railways*	*New South Wales Railw*
Date commenced work study . .	« Basic principles since 1920 » fully as defined since 1955.	Workshops before 1940 Other departments for « some decades ».	1957
Descriptions of work which has been studied	—	Motive power in shunting. Maintenance. Main workshops. Administration.	Workshops.
Techniques which are used regularly	Process charts, flow diagrams.	Process charts, flow diagrams. Time studies. Time studies (overall). Production studies. Activity sampling (except shops).	Flow diagrams, produ vity and time study.
System of rating and rating scale.		None.	—
Relaxation allowances	Allowances take into account all relevant factors with an average of 10 % - 15 % with a basic of 8 % and special cases up to 50 %.	$a + b + c + d$ where : a = clock time b = correction for skill c = correction for effort d = allowance for personal care	—
Extent of incentive schemes based on work measurement to work study standards	None.	None.	None.
Piecework schemes based on agreed times or prices	—	None. (Times set for tasks but no bonuses are paid.)	—
Other financial incentive schemes	—	Only for punched card operators.	—

ailway administration *(continued)*. — APPENDIX III *(continued)*.

Norwegian State Railways	*Rhodesian Railways*	*South African Railways*	*Swedish State Railways*
Workshops 1949 Other depts. 1950	1948	1957	1935
'orkshops. perating. ommercial.	Transportation. Offices. Other departments.	Transportation. Stores.	Permanent way. Machine shops. Traffic. Offices.
rocess charts, flow diagrams. me studies. roduction studies. ctivity sampling.	Process charts, flow diagrams, string diagrams. Time study, motion study. Production study. Activity sampling.	Process charts, flow diagrams. Time studies.	Process charts. Time and motion studies Activity sampling.
ormal rating system ontract work performance = 100	Effort rating 75 - 100 Standard = 100.	60 - 80 Standard = 80.	0 - 100 Normal (standard) = 100.
ommon production and perso- l allowance + special allowance r heavy work, bad conditions, dged on study man's experience collaboration with men's Work udy representative.	Allowances take into account all normal factors including allowances for process idle time.	Allowances vary with arduousness and intensity of work.	General 5 % for individual waste time in which waiting time for relaxation is included. Higher allowances in particular cases.
None.	None.	The piecework schemes are based on a form of work measurement which closely resembles that of Work Study.	None.
raight piecework in workshops nd on permanent way maintenance.	None.	Straight piecework in workshops based on accurately studied and calculated times.	Group piecework schemes in main workshops and at permanent way depots. Goods sheds and depots are now being applied. Bonus earnings in goods sheds are from 10-20 %.
—	—	Dredging, earthmoving and tunneling are paid on a Halsey 50/50 scheme.	—

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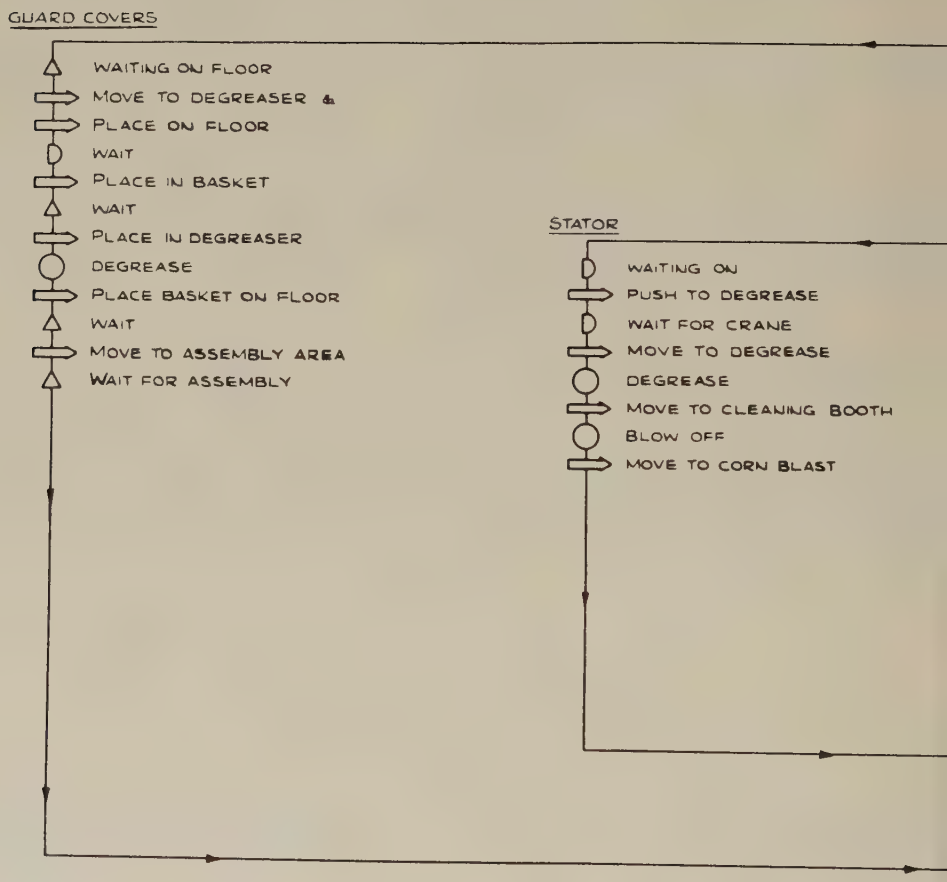
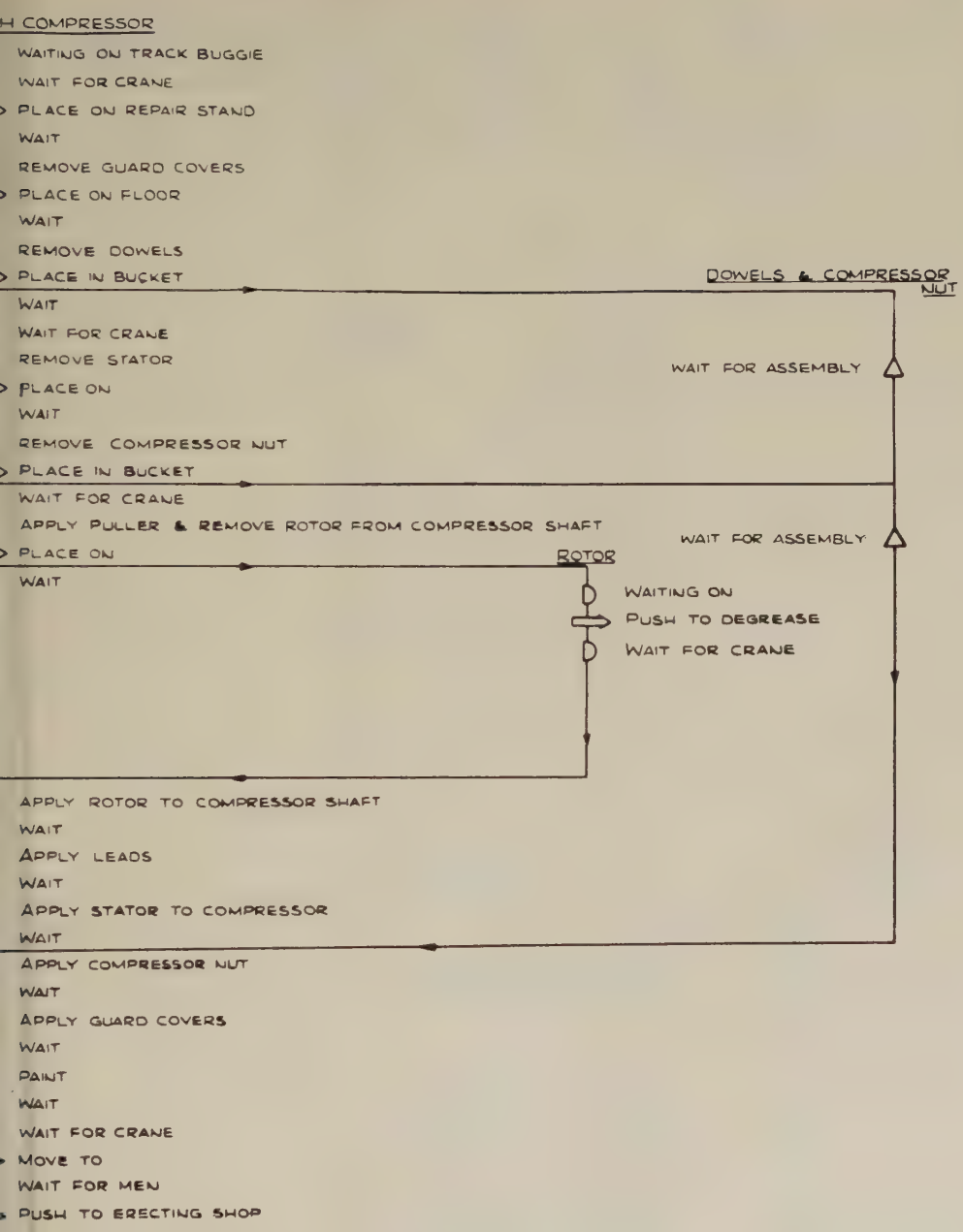


Canadian National Railways. Portion

APPENDIX IV.



hart. Assembly of alternator with compressor.

APPENDIX VI.

CASE STUDIES.

This selection of examples of the application of the scientific organisation of work in the manner commonly achieved by Work Study is drawn from cases quoted by railway administrations which replied to the questionnaire in English. They indicate decisively the value of applying Work Study techniques to all phases of railway work.

They are grouped here in nine categories according to the general nature of the work performed:—

A. Passenger Station Working:

1. Japan (J.N.R.) — Station Work Scheduling.
2. United Kingdom (B.R.) — Station Platform Duties.

B. Goods and Parcels Depot Working:

3. Norway (N.S.B.) — Reorganisation & Mechanisation.
4. Sweden (S.J.) — Mechanisation & Bonus Scheme.
5. United Kingdom (B.R.) — Parcels Depot.
6. South Africa (S.A.R.) — Reorganisation of Staff.
7. Rhodesia (R.R.) — Work Measurement.

C. Operating:

8. Netherlands (N.S.) — Shunting & Marshalling Reorganisation.
9. United Kingdom (B.R.) — Marshalling Yard Reorganisation.

D. Motive Power Running and Maintenance:

10. Norway (N.S.B.) — Locomotive Shed Duties.
11. Canada (C.N.R.) — Diesel Electric Inspection Shop.
12. United Kingdom (B.R.) — Inspection & Running Maintenance.

E. Passenger and Freight Stock Running and Maintenance:

13. Canada (C.N.R.) — Coach Servicing Yard.
14. Norway (N.S.B.) — Carriage Cleaning.
15. United Kingdom (B.R.) — Carriage Cleaning.

F. Mechanical and Electrical Engineering Workshops:

16. Indian Railways — Locomotive Works.
17. Canada (C.N.R.) — Layout of Electrical Winding Shop.
18. Germany (D.B.) — Workshop internal transport.
19. Netherlands (N.S.) — Coach and Wagon Repairs.
20. Irish Transport Company — Mechanical Engineering Workshops.

G. Civil Engineering and Signal Engineering:

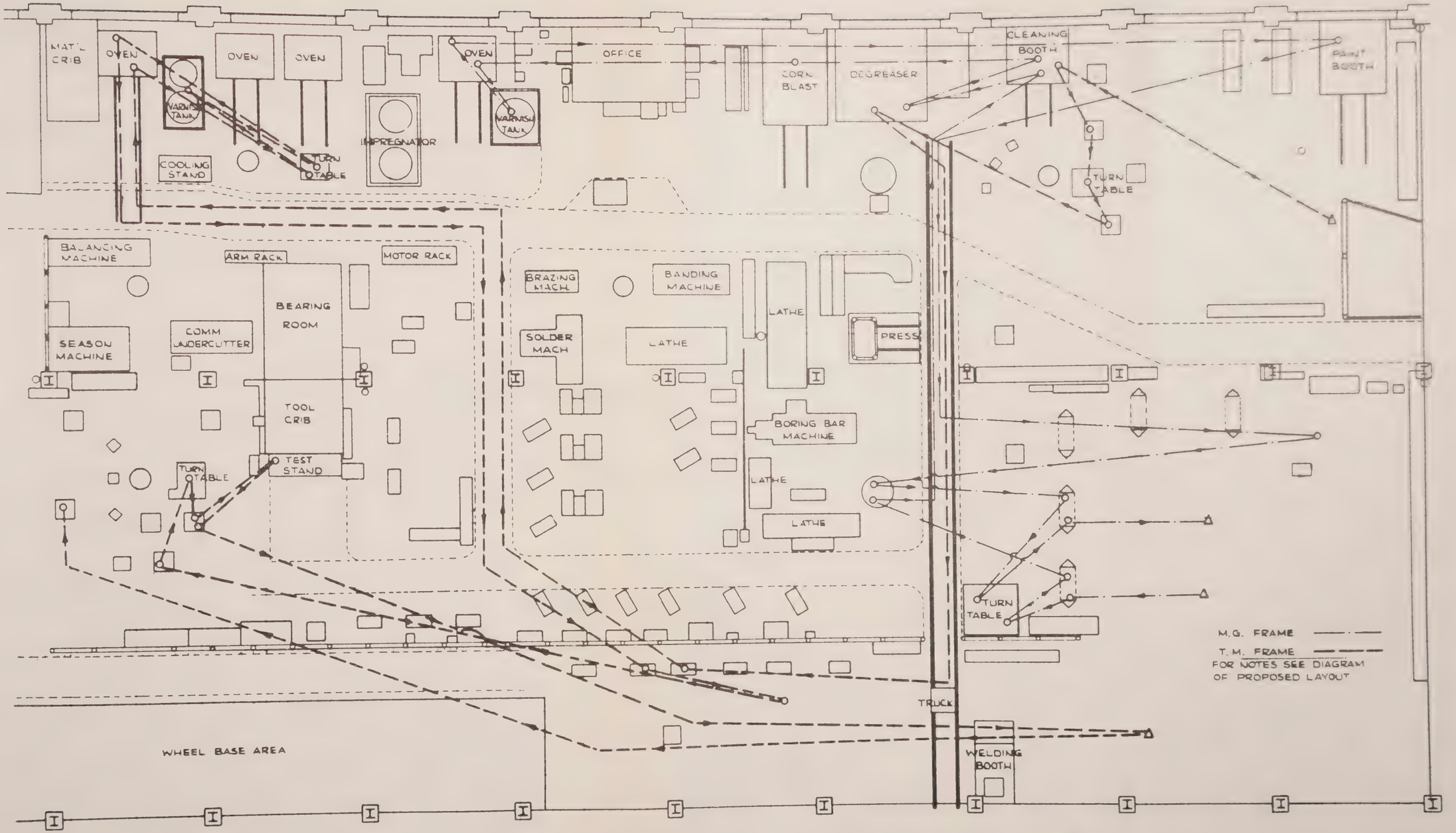
21. United Kingdom (B.R.) — Permanent Way Maintenance & Renewal.
22. Sweden (S.J.) — Permanent Way Maintenance.
23. United Kingdom (B.R.) — Signal Engineering.

H. Design of Railway Installations:

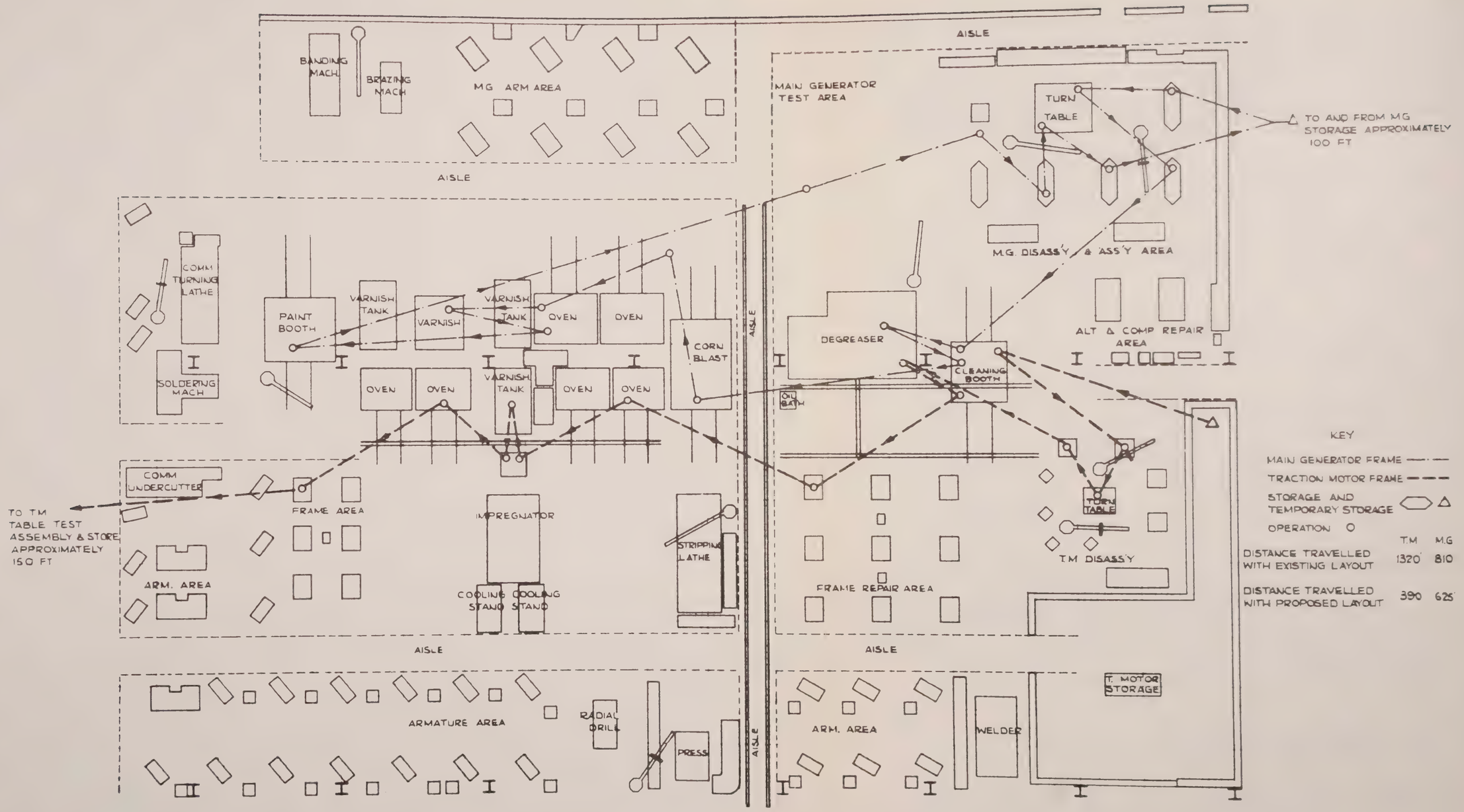
24. Sweden (S.J.) — Design of New Diesel Shed.
25. United Kingdom (B.R.) — Planning New Parcels Handling Area.
26. South Africa (S.A.R.) — Design of Train Staging Yard.

K. Office Work:

27. United Kingdom (B.R.) — Seat Reservation Office.
28. United Kingdom (B.R.) — Accountant's Office.
29. Irish Transport Company — Reorganisation of Typing Service.
30. South Africa (S.A.R.) — Collected Tickets Office.



Canadian National Railways. Flow diagram. Existing layout of winding shop.



Canadian National Railways. Flow diagram. Proposed layout of winding shop.

A. PASSENGER STATION WORKING.

1. Japanese National Railways.

Station work scheduling.

The station work schedule system has been studied and developed by this administration since 1948. It is now applied to some 60 % of all stations on J.N.R. An extract from a schedule, which is a form of *activity chart,* is shown in Appendix VI A. It enables Station Masters and their assistant Supervisors to grasp the working situation of their stations and employees. Uneven distribution of work is avoided and staff are more satisfactorily assigned to their various tasks. The schedules are also used in connection with training of station staff.

Between 1954 and 1957, the total of 130,000 staff was reduced by about 1,000 employees. In addition, the system has enabled J.N.R. to keep pace with the increasing demands of traffic over the last few years. Plans are based on the manning of stations with sufficient staff to provide a reserve of manpower of about 34 % which will allow for relaxation and for an increase of traffic of about 20 % without further increase in staff.

2. British Railways.

Station platform duties.

The fundamental technique used is again the *activity chart,* the purpose of which is very similar to that of the previous example described. The chart is illustrated in Appendix VI B and is the case of a medium sized station as shown by the plan in Appendix VI C. From the activity chart two further diagrams are prepared. The first, of which parts only are shown on the right-hand side of Appendix VI C, balances the work load between the various groups of station staff, so that any unnecessary division of duties is rectified. The work load is based on *work measurement* by time study and is based on a low enough performance for adequate balance of labour to cover any peak demands. The second of these diagrams, an abstract of which is shown below the plan of the station, is drawn for each group of platforms which can conveniently be served by the same group of staff. This shows the actual work load hour by hour, and on it are plotted the manning of each group providing for a movement of staff from one group to another to cover fluctuations in traffic. The available labour at normal and standard performances are both indicated. In the case illustrated these techniques enabled the average performance to be increased from one of 32 % to one of 68 %, with an appropriate reduction in staff.

B. GOODS DEPOT WORKING.

3. Norwegian State Railways.

Reorganisation and mechanisation.

At the commencement of investigations, this depot employed 75 staff to handle 270 tons of received and forwarded sundries each day. It consisted of three sheds with unloading and loading tracks between the sheds. After unloading inwards traffic, wagons were shunted to the outwards platforms for reloading. As a result of the study, one shed was abandoned and the other two sheds used for both inwards and outwards traffic without any intermediate shunting. New decks, additional tracks between the sheds, and mechanised handling with pallets and containers for internal handling, enabled the reorganisation to be made. This, in turn, resulted in a reduction of the staff to 55 and a reduction in shunting costs by 50 %. The new methods and plans were based on standard times which had been derived from time studies taken during previous investigations.

4. Swedish State Railways.

Mechanisation and bonus scheme.

During 1957, the work at Nässjö goods transhipment depot was reorganised and a bonus scheme was introduced. Extensive use is now made of fork-lift trucks, hoisting cars and loading pallets. By means of Work Study it was possible to establish the average number of parcels transhipped per hour whilst Normal Performance was maintained. All staff in the depot share equally in the group bonus scheme. The bonus is calculated monthly with full account being taken of days when performance falls below Normal. Full credit is given for time saved at an agreed rate above Normal and it is anticipated that a performance of about 40 % above Normal will ultimately be achieved. A reduction in staff of about 45 men or 40 % of the original number has produced a saving of 770,000 crowns a year. Deducting bonus payments

of 90,000 crowns, administration of 40,000 crowns and capital charges of 40,000 crowns a year, the resulting net annual saving becomes 600,000 crowns.

5. British Railways.
Parcels depot.

Work Study applied at a parcels handling depot enabled a total staff of 144, plus an additional 20 during the summer, to be reduced to 91. With the introduction of labour control through performance measurement, the reorganisation of the unloading sequence and removal of artificial demarcation of jobs, the reduced staff were able to handle an increasing volume of traffic so that the effective productivity was more than doubled to provide a saving of £18,000 a year.

6. South African Railways.
Reorganisation of staff.

At one goods depot, the use of Work Study resulted in the elimination of unnecessary work. The staff were thereby reorganised enabling the numbers to be reduced by nearly 50 %.

7. Rhodesian Railways.
Work measurement.

A Work Study investigation into the direct labour cost per ton of goods handling, together with the setting of standard minute values for this work in all areas, revealed possible reductions of labour to standard gang strengths. This provided central pool labour to cover absenteeism and resulted in an increase in productivity of more than 100 %.

C. OPERATING.

8. Netherlands Railways.
Shunting and marshalling yard reorganisation.

At Nijmegen improved planning and better utilization of tracks and locomotives resulted in part of the yard being closed and two engines and 13 staff being saved. Similar studies at Arnhem Goods Station showed that all shunting there could be undertaken by train engines so that its only shunting engine was no longer needed and the staff were reduced by five. Together these investigations revealed the capacity for further work at both stations. The work at the shunting and marshalling yards at Elst, halfway between Nijmegen and Arnhem, was studied and it was found possible to transfer all the work from Elst to these two stations. Of the 21 staff no longer required at Elst, only 4 had to be transferred with their work. In addition to the direct economies at Nijmegen, Arnhem and at Elst, the alterations resulted in an additional saving of 5 locomotives and their crews from other places in the vicinity.

9. British Railways.
Marshalling yard reorganisation.

An investigation into the work performed at a number of neighbouring goods marshalling and shunting yards showed that by some reorganisation it would be possible to close two of these yards. With a total staff of over sixty at the beginning of the studies an incentive bonus scheme was applied to those yards which were to be retained, which made it possible for all the work here to be performed by only forty men. When the other two yards are closed, only four more men will be needed at the central point where the total staff of 44 will be able to undertake all the work in the vicinity. The reduction of staff by 17 has produced a total saving of £15,000 a year, out of which some £5,000 a year is required for bonus payment.

D. MOTIVE POWER RUNNING AND MAINTENANCE.

10. Norwegian State Railways.
Locomotive shed duties.

Investigations in the Kristiansand and Stavanger Regions were put in hand with four objects in mind.

These were :—

(*a*) Improvement of methods of inspection;

(*b*) Preparation of detailed work specifications;

(c) Calculation of standard times for maintenance tasks;

(*d*) Correct allocation of work between sheds.

The investigations showed variations in practice between the regions. Standard practices have now been established in all regions.

The length of run between inspections has been increased and duplicated work has been eliminated. Ultimately it is expected that considerable savings will result from the co-ordination of running repairs.

11. Canadian National Railways.

Diesel electric inspection and running repair shop.

Assigned to this shop were some 250 locomotives and rail cars, on which vehicles' mileage inspections and heavy running repairs were carried out, trip inspections being handled elsewhere. Some 50-60 vehicles were inspected and repaired daily with a total staff of about 400. The shop was reorganised into work centres and a production and productivity measurement system was introduced. Further recommendations were also made which included proposals for additional supervisory training, for monthly meetings between Supervisors and management, for periodic review of inspection sheets, examination of control statistics and competent survey of shop's clerical duties. The results of the study included an increase of about 30 % on mileage inspection, a reduction in craftsmen of 22 %, and an annual saving of more than 200,000 dollars. It is claimed that using the more comprehensive method of work reporting which was instituted, the efficiency of the first inspection work centre was about twice that obtained by the rest of the shop at that time.

12. British Railways.

Locomotive inspection and servicing.

Detailed *method study* and *work measurement* in a depot where a total of 16 staff were employed to keep 36 locomotives in service, led to accurate work specifications and labour control. As a result, 16 further locomotives were attached to the depot and the number of additional locomotives which would have been required to cover unavailability during servicing was reduced from seven to two. Incentive bonuses were paid and no additional staff were needed. The savings realised amounted to a labour saving equivalent to £90,000 a year and a capital saving in spare locomotives equivalent to £25,000 a year.

At another depot an authorised staff of 82 had already been depleted to 74. Work Study was introduced leading to incentive bonus payments which enabled this number to be still further reduced. At the same time it became possible to increase the amount of work carried out at the depot. With some 70 locomotives allocated to the depot, the increase in productivity amounted to over 60 % with a saving of some £10,000 a year.

E. PASSENGER AND FREIGHT STOCK RUNNING AND MAINTENANCE.

13. Canadian National Railways.

Coach servicing yard.

The work of this yard includes all servicing of coaches ranging from routine trip inspections to heavy repairs. Over 500 craftsmen and assistants are employed to deal with nearly 10,000 vehicles each month. Studies were put in hand in January 1958. The changes which were seen to be necessary were put into effect during September and October and the five-man study group made its report in December of that year. The object was to increase productivity and to control operational costs by means or reorganisation, *work measurement* and improvement of facilities. The changes included (i) increased supervision, (ii) introduction of flexible work centres whereby gang sizes could be altered to meet work demands, (iii) the use of staff inspectors in place of craft inspectors for each trade, (iv) advance planning of maintenance and repairs, (v) introduction of material urge personnel. Reductions in staff had begun in 1956 so that by the time the reorganisation was complete a reduction of more than 200 staff, or 26 %, had been made. This resulted in net annual savings of 160,000 dollars.

14. Norwegian State Railways.

Carriage cleaning.

In connection with the modernization plan of 1958, the Organisation and Methods Office carried out a Work Study investigation of carriage cleaning methods. The investigation showed that by improved methods, more appropriate cleaning agents and soaps, and effective organisation, it was possible to reduce cleaning costs by 20 %, giving a saving of 1,900,000 kr. a year. The studies were made so that standard cleaning methods and rou-

tines might be instituted, including (*a*) analysis, evaluation and testing of methods, mechanical aids, cleaning agents and soaps, (*b*) modernisation of carriage sheds and design of new layouts, and (*c*) the compilation of work descriptions and standard times as a means towards planning and control of work.

15. British Railways.

Carriage cleaning.

Method study into the cleaning of carriages at one depot showed that the frequency with which many of the cleaning tasks were undertaken was not commensurate with the most efficient results and many tasks were found to be undertaken in the wrong sequence for effective cleaning. Alterations were made to the sequences, methods and frequencies with a view to improving the quality of work, as well as effecting economies. The work was measured, incentives were applied and, with a marked rise in the output in the form of cleaner coaches, a reduction of some 20 % in the equivalent staff was achieved by avoiding overtime. The performance was raised from 65 to 100.

F. MECHANICAL AND ELECTRICAL ENGINEERING WORKSHOPS.

16. Indian Railways.

Locomotive works.

At Chitteranjan Locomotive Works a productivity drive, coupled with the introduction of payment by results, has included the application of Work Study. Basic data for time standards was established and, supported by *method study*, has led to efficient production control. About 72 % of the 4,200 staff at the works are now covered. As a result, the total man hours per locomotive has been reduced from 70,000 to 50,000. The output has increased from 75.6 units to 164 units in five years with a corresponding reduction from 40.7 to 25.7 in numbers of staff per unit of output per year.

17. Canadian National Railways.

Layout of electrical winding shop.

A study of materials handling methods and shop layout in a winding shop, which was responsible for repairs to main generator traction motors and auxiliary electrical equipment on locomotives and trains, revealed the necessity for a completely new layout. Allowing 80,000 dollars for extensive new equipment, a saving of 28,000 dollars a year was realised with a direct increase of productivity of approximately 10 %.

18. German Federal Railways.

Workshop internal transport.

Rationalization of transport within workshops was so successful that capital invested in mechanical handling and transport of materials was recovered from the resultant savings within three years, even though the equipment had an estimated life of at least ten years.

19. Netherlands Railways.

Coach and wagon repairs.

A reorganisation of the work carried out in two wagon repair workshops indicated the possibility of economies by establishing a new division of work between these two shops. A saving of 15 % in equivalent labour was achieved in one year. By a similar study of major repairs of passenger rolling stock, a 10 % saving was achieved.

20. Irish Transport Company.

Mechanical engineering workshops.

Work Study was introduced in the workshops at Inchicore in 1957. Successful investigations were made into the repair of railcars and auxiliary equipment and of diesel electrical locomotives. The application of Work Study to the work of the Machine Shop has resulted in substantial savings in plant and manpower.

G. CIVIL ENGINEERING AND SIGNAL ENGINEERING.

21. British Railways.

Permanent way maintenance and renewal.

Detailed Work Study of the work of the permanent way length gangs provided information for accurate work specification and comprehensive standard data. Apart from an

increase in supervision and inspection, the original gang organisation was retained for administrative and psychological reasons. Appendix VI D illustrates the manner in which the principal operations of packing sleepers was planned to maximum productivity. In this particular case, four men performed more work in a given time than was previously performed in some instances by seven. An incentive bonus scheme in which men received a weekly bonus of one-third of their basic pay for standard performance has been introduced based on the times which had been determined for nearly all the tasks performed by the gangs. Effective labour control with performance indication ensures a continuing high productivity. As a result of the application, gangs have been reduced in size with a reduction in staff exceeding 25 %. In addition, the standard of maintenance has been greatly increased and, in some instances, length gangs have been able to undertake additional work previously carried out by extra gangs. This application is notable for its successful introduction to 30 % of all such staff on British Railways. Similar studies and schemes have been successfully extended to many other duties of civil engineering maintenance, including station and depot repairs, painting, bridge repairs and new construction.

22. Swedish State Railways.
Permanent way maintenance.

By means of Work Study the track maintenance on main lines has been reorganised. Operations have been measured by timing and rating. The work has been rationalised into a system in which all necessary maintenance tasks are carried out simultaneously at predetermined intervals. Reorganisation of the work which made increased mechanisation possible and produced an appreciable reduction of staff is of particular value in this administration in view of the problems of the seasonal utilization of such labour.

23. British Railways.
Signal engineering.

An application of Work Study followed by the introduction of incentive schemes to the work of Signal Linemen, similar to those for permanent way maintenance gangs, met with equal success, and similar economies were effected. In this case inventories were made of all equipment to be maintained. The frequency of maintenance tasks was determined for each item of equipment and thereby the the entire work load for each Lineman's area could be determined and the staff allocated suitably. The indirect economies from such applications of Work Study were found to lie in improved maintenance, fewer failures and longer life of equipment.

H. DESIGN OF RAILWAY INSTALLATIONS.

24. Swedish State Railways.
Design of new Diesel shed.

A new diesel shed, which came into use in 1958, was designed on entirely new principles. Work Study was used to determine the layout, the correct equipment and the correct number of staff required. The result was that a small depot nearby which employed 21 men was closed altogether. At the same time it was possible to reduce the numbers employed at the main depot by a further 16. Altogether this produced a reduction in operating costs of about 600,000 Swedish crowns a year. The design enabled all servicing, including inspection cleaning and refuelling, to be carried out in a building set aside for the purpose. A central control panel controls the doors, the conductor rails and exhaust hoods and all tools and equipment are arranged so that the staff need only walk one or two steps to find what is wanted. Over 120 locomotives are serviced and given minor repairs each day by means of this installation.

25. British Railways.
Planning new parcels handling area.

Plans for the merging of two large stations in a provincial town included the construction of new accommodation with equipment for handling all the parcels which had previously been handled by the two stations and by four smaller stations in the vicinity. Existing records were studied to discover broad fluctuations and trends of traffic. A census was taken of representative samples of traffic from each train over a period to discover accurately the contents of train loads and the detailed flow of parcels. Each task involved in the unloading, handling, sorting and loading of parcels was studied carefully with the aid of

method study and *work measurement,* including *activity sampling.* It became possible to quantify all traffic flows and the space and labour necessary to deal with them. As a result, the new layout was planned with confidence as to its suitability. Plans which had already been made without the quantified data were found to be capable of simplification, and an initial economy of about £130,000 was made.

26. South African Railways. Design of train staging yard.

A study which was carried out into proposals for the provision of additional yard facilities for staging trains resulted in the adoption of an alternative suggestion. This provided better facilities and cost only one-fifth of the original proposal.

K. OFFICE WORK.

27. British Railways. Seat reservation office.

A large terminal station employing 26 staff on the reservation of train seats was studied enabling fundamental organisation and method changes to be made. The new method provided a more effective system of seat reservation which was of benefit to the passengers. At the same time the staff was reduced to 23 and annual savings of about £2,000 a year made.

28. British Railways. Accountant's office.

In one Signal Engineering Accounts Office a method for greatly improved and prompter information for control over expenditure was evolved. Overtime was reduced and the staff reduced from 21 to 19, producing a saving in excess of £1,000 a year.

29. Irish Transport Company. Reorganisation of typing service.

The creation of a central typing bureau at the Traffic Manager's head office, complete with dictaphone and telecord machines produced a saving of 16 shorthand typists. A bonus scheme was introduced based upon the average number of dictabelts completed per hour. A steeply rising bonus from £4 for one belt per hour to £7.10s for 1⅓rd belts per hour was paid.

30. South African Railways. Collected tickets office.

Work Study applied to a collected tickets office resulted in the introduction of suitable sorting equipment and in the reduction of staff by 45 %.

APPENDICES VI A, B, C and BIBLIOGRAPHY.

This is intended to assist readers to identify the principal works to which reference is made in this report. It is in no way a bibliography of the subjects discussed. Bibliographies will be found in several of the works in this list.

International Railway Congress Association :

AMBROZOVICS, Bela : *Premiums to interest staff in economies and increased receipts.* Question XX, 1889.

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SOULEZ, E. and BLOCH, M. (Special Report based on 3 reports) : *Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.* Question X, 1933.

Centres d'Études et de Mesures de Productivité : *Concepts et Terminologie de la Productivité.* Paris, about 1955.

European Productivity Agency : *Productivity Measurement.* Volume I, Concepts. Volume II, Plant Level Measurement. O.E.E.C. Paris, 1955.

International Labour Office : *Introduction to Work Study.* Geneva, 1958.

British Standards Institution : *Glossary of Terms in Work Study.* London, 1959.

Duty No.	Total No. of Employees	No. of Jobs	Turns of Duty	Extract from Work Diagram from 12 hrs to 17 hrs (in practice the entire 24 hrs are charted as indicated by summary) — Time: B Station (next stn) / Y Station (this stn) / C Station (next stn)	Summary — Net Duty Hours: Work Hours: A Work	Non-work in A Work	B Work	Sub-Total (S)	Non-work Hours	Total (T)	Resting and Sleeping Hours	Total Duty Hours	Total Non-work Hours	Working Efficiency % (S/T × 100)
11	5	1	Daytime Duty	Ticket Examiner (examining and collecting tickets and other general supervisory work)	281		58	339	126	465	45	510		73
					176	48	58	282	183	465	45	510	231	50
12		1	24 hr Duty	Ticket Examiner (collection)	659		4	663	417	1080	360	1440		61
					337	198	4	539	541	1080	360	1440	739	32
13		1	24 hr Duty	Ticket Examiner (Examination-Punching)	746		32	778	302	1080	360	1440		72
					487	84	32	603	477	1080	360	1440	561	48
14	2	1	24 hr Duty	Station Clerk (operating telegrams preparing station statistics and reports	578		28	606	474	1080	360	1440		56
					390	58	28	476	604	1080	360	1440	662	39

Notes.

1. Working hours are indicated in two rows for each job. The upper row shows the work recorded and reported from the station (γ station). The lower row shows the same work amended by the divisional railway operating office.
2. The black lines indicate « actual work ». The white lines indicate « un-worked (reserve) time ».
3. The diagonal lines indicate work eliminated by the divisional office.
4. This station, « γ station », is manned by a total budgeted number of 120 employees, with a total of 70 jobs. It handles passenger and freight traffic.

Key.

A 4. — Accepting and sending railway telegrams.
A 5. — Accepting and sending public telegrams.
AD. — Accepting and delivering railway telegrams.

C 6. — Correcting clocks.
C 7. — Collecting tickets from arrival passengers.

D. — Delivery of railway telegrams.

P 2. — Punching tickets for departing passengers.

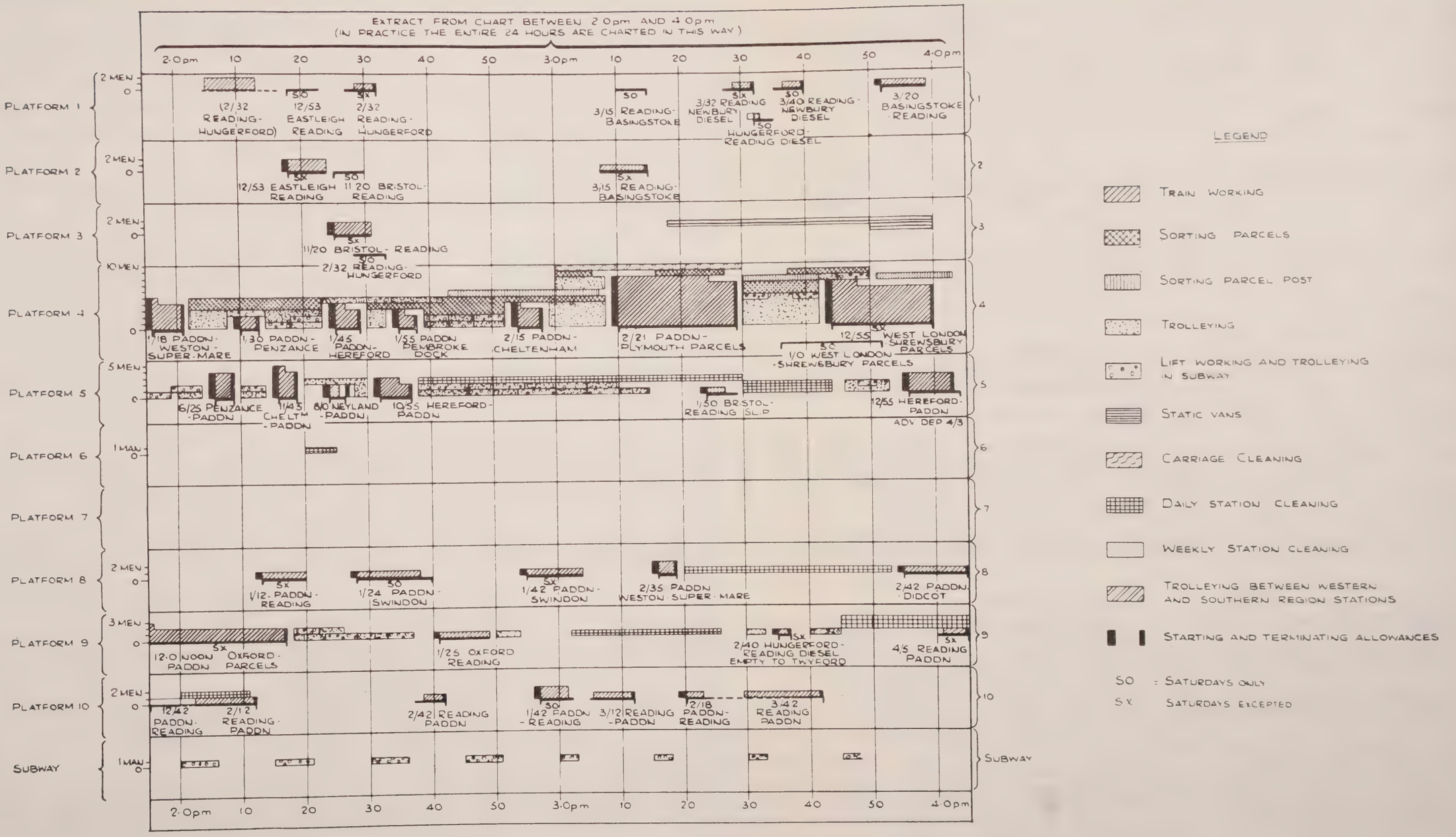
R 2. — Registering additional fares collected.
R 4. — Rechecking daily report for additional fares collected.
R 8. — Receiving railway telegrams from other stations.
R 8 D. — Receiving and delivery railway telegrams from other stations.
R 10. — Receiving, copying and sending railway telegrams.
R 21. — Registering number of passengers originated.
R 24. — Reporting number of passengers originated.
R 26. — Rest hours.
R 27. — Refunding passenger fares.

S 2. — Sending and receiving public telegrams.
S 4. — Sorting arrival tickets collected.
S 7. — Sweeping floor around wicket.
S 8. — Sweeping inside office.

T 3. — Transferring cash to station master.

Japanese National Railways. Activity chart (work diagram) of station duties.

In practice each train is numbered on the diagram above as is also the work it involves on the activity chart itself.



British Railways. Activity chart of station duties.

[385 (06 .111]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Enlarged Meeting of the Permanent Commission, held in New Delhi.

(7th to 9th December 1959).

The Permanent Commission held at New Delhi from the 7th to 9th December 1959, several technical sessions which were attended by a certain number of its members as well as by their assistants : engineers and high officials, belonging to the main Railway Systems.

The programme of the technical sessions included the study of the following question :

« Problems met in the design of multi-current rolling stock. Existing types : experimental results. Future developments. »

The study of this question was decided at the Meeting of the Permanent Commission, which took place on the 7th March 1959.

The list appearing in *Appendix* 2, pages 312 of the present *Bulletin* gives the names of the members of the Permanent Commission and their assistants, who attended the technical meetings.

[385 (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

Meetings held by the Permanent Commission at New Delhi (7th to 9th December, 1959).

The inaugural ceremony took place on Monday 7th December at 9.30 a.m. This meeting was enhanced by the presence of His Exc. the Minister of Railways, SHRI JAGJIVAN RAM.

Mr. DE VOS, *President of the Association*, thanked the Minister of Railways, whose presence gave evidence of his interest in the progress of the Railways and in the works of the Association.

He expressed his gratitude to the Indian Government for having invited the Permanent Commission of the Association to hold its Enlarged Meeting in India.

Speaking of the technical programme, he paid a special tribute to the works of the Reporters, who studied the question on the Agenda of the Meeting.

Finally, he expressed the wish that the Indian Railways be the first to have the privilege of sharing in the benefits of the technical works taking place in New Delhi.

His Exc. the Minister of Railways wished a most cordial welcome to the participants to the meeting and pointed out the importance of the question discussed, particularly for the railways of his country, at present involved in a tremendous effort of modernisation.

He recalled the relationship of long standing existing between India and the Association and expressed his faith in international cooperation of which the Association is a striking example. Then, he declared open the Enlarged Meeting of the Permanent Commission.

THE PRESIDENT thanked the Minister of Railways for his most interesting speech and adjourned the session.

* * *

MEETING OF THE PERMANENT COMMISSION HELD ON DECEMBER 7, 1959.

A first meeting of the Permanent Commission was held on the 7th December 1959 at the Vigyan Bhavan in New Delhi.

The session, which opened at 10.30 a.m., was presided by Mr. M. DE VOS, *General*

Manager of the Belgian National Railways and President of the Association.

After having extended a warm welcome to the numerous personalities present, the President expressed on behalf of the Assembly, his most sincere thanks for the hearty welcome received in India. Then, he opened the discussion of the Agenda.

He submitted to the approval of the Meeting the Minutes of the Session of the 7th March 1959, which were approved.

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The President then paid a tribute to the memory of Mr. R. da Costa Couvreur, Engineer, former President of the High Council of Public Works, Ministry of Public Works and Communications of Portugal, who deceased on June 24, 1959. He recalled his devotion to the Association since his appointment as member of the Permanent Commission in 1930, and in particular the active part he took in the works of the Lisbon Enlarged Meeting of 1949. When he retired in 1949, he was unanimously nominated Member of Honour.

Then, Mr. Ghilain, *General Secretary*, informed the Meeting of the other modifications which occurred in the constitution of the Permanent Commission.

After announcing the retirement of Mr. Mohamed Halim El-Rashid, General Manager of the Egyptian Railways, whose mandate is now vacant, he submitted the following proposals for the nomination of members of the Permanent Commission:

Mr. L. J. Dunnett, Permanent Secretary, Ministry of Transport and Civil Aviation (Great Britain) to replace Sir Gilmour Jenkins, who has retired. Mr. Dunnett will also succeed to Sir Gilmour Jenkins as a member of the Executive Committee;

Mr. K. B. Mathur, Chairman, Railway Board, Ministry of Railways, Government of India, to replace Mr. P. C. Mukerjee, who has retired for health reason;

Dr. C. S. Andrews, Chairman of the Coras Iompair Eireann (Republic of Ireland), to replace Mr. T.C. Courtney, retired;

Mr. F. Boomstra, Chief Engineer, Ministry of Transport and Waterstaat (Netherlands), to replace Mr. Dijkmans van Gunst, deceased;

Mr. O. Wichser, General Manager, Chief of the Works and Operating Department of the Swiss Federal Railways, to replace Mr. Cottier, former Director of the Central Office of International Railway Transports;

Mr. Dj. Savićević, Deputy General Manager of the Jugoslav Railways, to replace Mr. J. Svagel, former Director of the Railway Institute of this system.

— *These proposals were adopted by the Meeting.*

— *The Appendix No. 1, hereafter gives the present list of members of the Permanent Commission.*

* * *

The General Secretary then made a statement about the organisation of the

Enlarged Meeting to be held in Brussels, at the end of June next, to commemorate the 75th anniversary of the Association. He mentioned that the Special Commission, set up for the purpose, held two meetings during which the following proposals were submitted :

The meeting will begin on Monday, June 27, and will be closed on Saturday July 2. The proposed programme was adopted. Technical sessions will take place during three days and the other three days will be devoted to technical visits, etc.

The meetings will be held in the « Palais des Congrès ». Arrangements have been made for the reservation of the conference rooms needed for the reception of the delegates and ancillary services.

A series of commemorative stamps will be issued for this 75th anniversary of the Association.

Then, Mr. GHILAIN informed the Assembly of the progress of the preparatory works in view of the Brussels Meeting. The publication of the reports on the three technical questions on the agenda, was started in the *Bulletin* for January 1960 and will continue during the first months of the present year. The special reports, with the draft summaries, will appear in the Bulletin in due course.

He gave also the names of the personalities proposed to preside over the discussions during the technical sessions. These Presidents of Section are designated hereafter :

Section I : Mr. d'ARBELLA, Inspecteur en Chef Supérieur au Service de la Traction et du Matériel des Chemins de fer de l'Etat italien;

Section III : Dr. F. SCHELP, Mitglied des Vorstandes und Präsident der Deutschen Bundesbahn.

Section IV : Sir John BENSTEAD, Deputy Chairman of the British Transport Commission.

— *These proposals were unanimously approved.*

* * *

Concerning the changes in membership since the Meeting of the 7th March 1959, Mr. GHILAIN announced the resignation of two members : the « *Compagnie belge des Chemins de fer et d'Entreprises* » (28 km) and the « *Compagnie Générale d'Entreprises électriques et industrielles* (*Electrobel*) » (38 km), which have ceased to operate railway lines.

In addition, the Swedish Company, *Stockholm-Roslag* (288 km) has been amalgamated with the Swedish State Railways.

A request for membership has been received from the « Office National des Chemins de fer de Guinée » (673 km).

The International Railway Congress Association includes now 34 Governments, 10 Organisations and 101 Administrations with a total mileage of 601 704 km (373 000 miles approx.)

* * *

The Meeting ended by the examination of the financial position of the Association.

Before closing the session, the PRESIDENT proposed to hold a meeting of the Permanent Commission towards the end of February 1960, in order to examine

in particular the measures considered for the organisation of the Brussels Enlarged Meeting.

— *This proposal was approved.*

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MEETING OF THE PERMANENT COMMISSION OF THE 9th DECEMBER 1959.

The meeting held at the *Ashoka Hotel* opened at 10 a.m. under the chairmanship of Mr. M. De Vos, *President of the Association.*

The President stated that the only item on the Agenda was the ratification of the Summaries adopted by the Section during the technical meetings.

The text of the Summaries was approved without modification.

The General Secretary, (s) P. Ghilain. *The President,* (s) M. De Vos.

* * *

The technical meetings, which took place at Vigyan Bhavan, started on the 7th December at 2.15 p.m. The Section examined the Special Report drafted on the question on the agenda and interesting discussions, in which took part the representatives of the main railway systems, occurred.

A second session was held on December 8, and the Summaries proposed by the Special Reporter were discussed to be finally submitted to the approval of the Plenary Meeting of the Permanent Commission on December 9.

This meeting was held at the *Hotel Ashoka* in New Delhi.

The Assembly, under the chairmanship of Mr. De Vos, examined the summaries proposed by the Bureau of the Section. They were adopted without modification.

— *These Summaries are reproduced pages 331/335 of the present Bulletin.*

* * *

During the evening, on December 7, a reception was organised by the Indian Government at Baroda House, it was followed by a banquet at Hyderabad House, which was attended by all the participants to the meeting as well as by numerous personalities of the Indian Railways. This banquet, presided by *His Exc. the Minister of Railways*, Shri Jagjivan Ram, accompanied by Shri K. B. Mathur, *Chairman of the Railway Board*, and Mr. M. De Vos, *President of the Association.*

A speech was delivered by the *Minister of Railways* and Mr. De Vos, President of the Association, replied on behalf of all the Delegates and expressed once more whole-hearted feelings towards India for its tremendous efforts realised in order to increase the standard of life of its people.

The following day, December 8, the Permanent Commission offered a Banquet to the Indian Authorities and to its members. Speeches were made by Mr. De Vos, *President of the Association* and by Shri Jagjivan Ram, *Minister of Railways.*

On Wednesday, December 9, the delegates participated to sightseeing tours in New Delhi and were able to visit some famous ancient monuments.

The following day, a special train with air-conditioned coaches of great comfort, built in India, took the participants for a four-day tour to Calcutta, via Agra and Banaras. During that excursion, the participants were able to visit the marshalling yard of Mughalsarai as well as the huge workshops of Chittaranjan, where all the steam locomotives necessary for India are now being built and which soon will also supply all the electric locomotives needed.

At Calcutta, the delegates were able to see the 25 000 V electrification works being at present undertaken in the western part of this city.

While a party of delegates were going to Madras, the others were directed to Bombay, and there they were able to inspect an electrified line at 1 500 V.D.C., with a section of 25 km having a steep gradient of 30 mm/m.

More detailed particulars about these technical visits are given further on.

Receptions marked by the greatest cordiality took place in most of the places visited and the participants will keep moving and grateful memories towards the Government of India, the representatives of the *Railway Board* and of the various railway systems concerned.

* * *

The Indian Government Railways organised for the participants several technical visits, which are summed up hereafter :

TECHNICAL VISITS.

1. Electrification.

1 500 V D.C.

1 500 V D.C. has been used in the Bombay region since 1925, both on the Central Railway and on the Western Railway.

This electrification is concerned primarily with the outer suburban traffic of Bombay.

Between 1938 and 1958, the passenger traffic increased by 372% on the W.R., whilst on the C.R. it has increased by 455% in thirty years.

The members of the Permanent Commission made a run on the C.R. from Bombay to Lonavla with a stop at Kalyan in order to visit a substation (22 kV primary supply, three groups each having two 750 V rotary converters in series) and the central remote control post for the substations and sectioning points.

The rolling stock (1 676 mm gauge) includes, taking the C.R. and W.R. together : 139 four-unit rail motor coaches and 73 locomotives.

The special train was hauled by a 123 t CoCo locomotive (3 600 H.P. at the hourly rating).

The Kalyan-Lonavla run includes a section of about 25 km on a steep gradient (30 mm/m).

1 500 V D.C. is also used in the Madras region (Southern Railways).

3 000 V D.C.

The electrification of the suburban lines around Calcutta was decided upon in 1954, and put into service in 1957 (141 km of lines, 450 km of track, 3 000 V D.C.).

The stock includes 47 three-unit rail motor coaches (1 000 H.P. at the hourly rating) and 15 locomotives of 3 120 to 3 600 H.P.

During the run from Burdwan to Calcutta, (Eastern Rys.), a visit was made to the Howrah shops, which are responsible for the maintenance of the electric rolling stock.

The Permanent Commission was present at the inauguration of a section of line on the Raj Kharsawan-Dangoaposi line.

The first locomotive from the European firms was taken to the site and put into

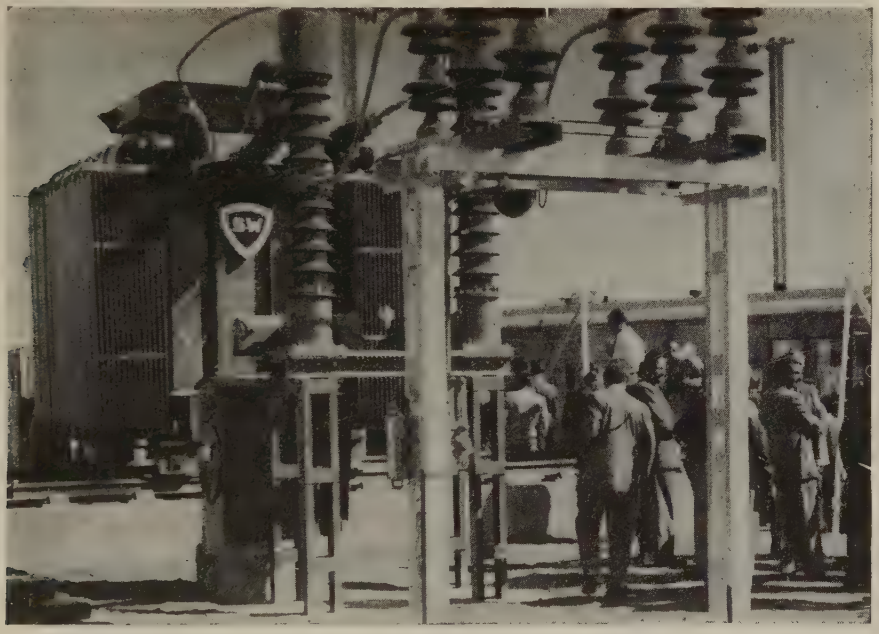

Fig. 1. — Sub-station at Kendposi.

25 kV - 50 cycles single phase current.

The second five year plan (1956-1961) covers the electrification of 1 325 km of lines using 25 kV - 50 cycles single phase current.

This project covers lines in the Bombay and Madras regions as well as lines in the industrial area to the west of Calcutta (coal mines and heavy industry).

For this purpose, 100 locomotives have been ordered from a group of European firms and 10 from Japan.

traffic, thanks to the S.N.C.F. which lent the necessary equipment for the Kendposi substation.

This inauguration took place on the 15th December. The efforts made to accomplish this will be appreciated when we point out that all the equipment for the substation was still in the port of Calcutta on the 30th November.

The characteristics of the locomotive are as follows : Type B'o B'o (1.676 m gauge);

Length over buffers : 15 937 mm;
Weight : 75.2 t;
Maximum speed : 112.6 km (70 miles)/h.
Continuous rating : 2 890 H.P. — 52 km/h — 14 500 kg;
Gear ratio : 1 : 4.06;

2 340 t at 48 km/h on gradients of 5 mm/m.
Starting 3 660 t on gradients of 1.6 mm/m and 2 340 t on gradients of 5 mm/m.

Of the 100 locomotives ordered from Europe, 69 will be designed for driving as multiple units.

Fig. 2. — Locomotive built in the Chittaranjan Locomotive Works.

No. of traction motors : 4;
No. of ignitron rectifiers : 4.

The traction programme is as follows :
Passenger service :

686 t at 112.6 km/h on the level;
686 t at 88.5 km/h on gradients of 5 mm/m;
686 t at 72.4 km/h on gradients of 10 mm/m;
686 t at 64.4 km/h on gradients of 12.5 mm/m.

Goods service :

3 600 t at 64 km/h on the level;

2. Mughalsarai marshalling yard.

418 miles (670 km) from Howrah (Calcutta) lies the Mughalsarai marshalling yard, the link between the Eastern and Northern Railways.

On its 130 miles (210 km) of track, it deals with an average of 2 300 wagons a day in both directions (peaks of 511 wagons in September 1959).

The yard employees number 7 000.

The yard is 4 miles (6.4 km) long and

has four main ladder tracks, one of which has 35 tracks.

During the second five year plan, it is proposed to extend this yard, improve the signalling, fit track brakes, and do away with certain crossings by building some new bridges.

3. Chittaranjan Locomotive Works.

The Chittaranjan Locomotive Building Works were created by the Government of India some ten years ago.

5 000 men are employed.

A town has been built around the works, covering an immense acreage, where spacious houses surrounded by gardens have been erected, with the necessary standard of comfort (water and electricity supplies), and which are rented to the staff on advantageous terms.

At present, the C.L.W. can build about 200 steam locomotives (2-8-2 type) a year.

The supplementary services (technical schools, hospital, various services assured in the town) occupy about 3 000 employees.

At the present time, the Works are getting ready to build 10 D.C. electric locomotives, and 42 single phase locomotives.

Our visit to these Works left us with an impression of orderliness and remarkable organisation.

4. The Madras shops.

The coach building shops at Perambur near Madras (Eastern Railways) were visited by some members of the Permanent Commission.

These shops build the most up-to-date designs of metal coaches and their machine tool equipment is in no way inferior to the best European shops.

As at Chittaranjan, the installations are completed by schools, canteens, accommodation for the staff, etc.

Production exceeds one coach per day (22 m long coaches for 1 676 mm gauge).

List of Members of the Permanent Commission

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(DECEMBER 7, 1959.)

President :

M. **De Vos** (1), Directeur Général de la Société Nationale des Chemins de fer belges; 19, rue du Beau-Site, Bruxelles.

Vice-Presidents :

J. **Goursat** (2), Directeur de la Région du Nord de la Société Nationale des Chemins de fer français; 18, rue de Dunkerque, Paris (X^{e});

M. **Crem** (2), Directeur du Service de l'Exploitation de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles.

Members of the Executive Committee :

E. **Dorges** (1), Secrétaire Général Honoraire aux Travaux Publics et aux Transports, Délégué Général aux Affaires Internationales du Ministère des Travaux Publics, des Transports et du Tourisme; 244, boulevard Saint-Germain, Paris;

Sir John **Benstead** (2), Deputy Chairman of the British Transport Commission; 222, Marylebone Road, London, N.W.1;

L.J. **Dunnett** (3), Permanent Secretary, Ministry of Transport and Civil Aviation (Great Britain); Berkeley Square House, Berkeley Square, London, W.1.

Ex-presidents of session, members ex-officio :

D^{r} Ing. G. **di Raimondo**, Directeur Général des Chemins de fer italiens de l'Etat (*retired*); Rome;

Ibrahim Fahmy **Kerim**; Le Caire;

D^{r} W. **Meile**, ancien Président de la Direction générale des Chemins de fer fédéraux suisses; Brügglerweg, 11, Berne;

A. **Plana**, Sous-Secrétaire d'Etat aux Travaux Publics et Président du Conseil d'Administration du Réseau National des Chemins de fer espagnols; Madrid.

General Sir Brian **Robertson**, Bart., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C., Chairman, British Transport Commission, 222, Marylebone Road, London, N.W.1.

Members :

E.T. **Aalto** (1), Directeur Général des Chemins de fer de l'Etat de Finlande; Helsinki;

Mohamed **Afifi** (1), Directeur Général Adjoint des Chemins de fer de la République d'Egypte; Le Caire.

Dr. C.S. **Andrews** (1), Chairman of the Coras Iompair Eireann; Kingsbridge Station, Dublin;

Abdel Moneim **Azmy** (1), Sous-Secrétaire d'Etat au Ministère des Communications d'Egypte; Le Caire;

Sir John **Benstead** (already named);

R. **Besnard** (3), Chef de Service adjoint au Directeur général des Chemins de fer et des Transports, Ministère des Travaux publics, des Transports et du Tourisme; 244, boulevard Saint-Germain, Paris;

David **Blee** (1), General Manager, London Midland Region, British Railways; Euston Station, London, N.W.1;

Ing. F. **Boomstra** (1), Ingénieur en Chef au Ministère des Transports et du Waterstaat; La Haye;

Dr. H. **Born** (2), Directeur de l'Union d'Entreprises Suisses de Transport; Bundesgasse 28, Berne;

Dr. L. **Branca** (1), Vice-Directeur Général des Chemins de fer italiens de l'Etat; Rome.

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(1) Retires at the 18th session.
(2) Retires at the 19th session.
(3) Retires at the 20th session.

A. **Brouckaert** (3), Directeur du Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

E. **Clarembaux** (1), Directeur du Service de la Voie de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

M. **Crem** (already named);

G. **Csanadi** (2), Premier Adjoint du Ministre des Communications et des Postes (Hongrie); Budapest;

Dr Ing. A. **Cuttica** (1), Directeur Général Adjoint et Conseiller d'Administration des Chemins de fer italiens de l'Etat; Rome;

Ph. **Dargeou** (1), Directeur Général de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe);

J. **de Aguinaga** (3), Directeur Adjoint du Réseau National des Chemins de fer espagnols; Madrid;

E. **Derijckere** (3), Directeur du Service de l'Electricité et de la Signalisation de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

M. **De Vos** (already named);

M. **Dias Trigo** (2), Directeur des Services d'Exploitation et du Matériel de la Direction des Transports terrestres au Ministère des Communications du Portugal; Lisbonne;

Dr Ing. G. **di Raimondo** (already named);

E. **Dorges** (already named);

A.R. **Dunbar** (2), Manpower Adviser, British Transport Commission; 222, Marylebone Road, London N.W.1;

Sir John **Elliot** (2), Chairman of the London Transport Executive; 55, Broadway, Westminster, London, S.W.1;

J.M. **Garcia-Lomas** (3), Vice-Président du Conseil d'Administration du Réseau National des Chemins de fer espagnols; Madrid;

H. **Geitmann** (1), Präsident der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

Dr. Ing. P. **Giobbe** (1), Directeur du Service du Personnel et des Affaires Générales des Chemins de fer italiens de l'Etat; Rome;

J. **Goursat** (already named);

K.W.C. **Grand** (3), Member, British Transport Commission ; 222, Marylebone Road, London, N.W.1;

Dr H. **Gschwind** (3), Président de la Direction Générale des Chemins de fer fédéraux suisses; Berne;

R. **Guibert** (3), Directeur Général Adjoint de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe);

F. **Hebert** (3), Directeur Général Adjoint de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe);

R. **Hoens** (2), Directeur Général de la Société Nationale belge des Chemins de fer vicinaux; 14, rue de la Science, Bruxelles;

I.A. **Ivanov** (2), Candidat des Sciences Techniques, Directeur de l'Institut Scientifique des Chemins de fer de l'U.R.S.S.; Moscou;

M. **Jacobshagen** (3), Ministerialdirektor, Leiter der Betriebsabteilung in der Hauptverwaltung der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

Ibrahim Fahmy **Kerim** (already named);

Dr. Ing. Moustapha **Khalil** (2), Ministre des Communications d'Egypte; Le Caire;

A. **Kriz** (1), Ingénieur, Conseiller Supérieur de Section au Ministère des Communications de la République tchécoslovaque; Prague;

R. **Kunz** (3), Directeur de l'Office fédéral des transports; Berne;

Dr N. **Laloni** (2), ancien Directeur Général Adjoint des Chemins de fer italiens de l'Etat; Rome;

Brig. Ch.A. **Langley** (3), Chief Inspecting Officer of Railways, Ministry of Transport and Civil Aviation; Berkeley Square House, Berkeley Square, London, W.1;

J. **Lohmann** (2), Président des Chemins de fer Néerlandais, S.A.; Utrecht;

D.P. **Loomis** (1), President, Association of American Railroads; Transportation Building, Washington, 6. D.C.;

P. **Lorenzo Ochando** (3), Director General de Ferrocarriles, Tranvias y Transportes por Carretera; Madrid;

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(1) Retires at the 18th session.
(2) Retires at the 19th session.
(3) Retires at the 20th session.

W.H. **Maass** (1), Advisory Engineer to the High Commissioner for the Union of South Africa; South Africa House, Trafalgar Square, London, W.C.2.;

L.T. **Madnani** (3), Railway Adviser to the High Commissioner for India in London; Government Building, Bromyard Avenue, Acton, London, W.3.;

M. **Malderez** (3), Secrétaire Général du Ministère des Communications de Belgique; 17 *a*, rue de la Loi, Bruxelles;

R.F. **Marriott** (2), Advisory Engineer, Representative of the New Zealand Government Railways, New Zealand House; 415, Strand, London, W.C.2;

K.B. **Mathur** (1), Chairman, Railway Board, Ministry of Railways, Government of India; New Delhi;

Dr W. **Meile** (already named);

Ing. Z. **Modlinski** (3), Sous-Secrétaire d'Etat au Ministère des Communications de Pologne; Varsovie;

J.P. **Musquar** (2), Directeur Général de la Société Nationale des Chemins de fer Luxembourgeois; 17, rue du Nord, Luxembourg;

P. **Nolet de Brauwere** (1), Secrétaire Général Honoraire de la Société Nationale des Chemins de fer belges; 121, avenue F. Lambeau, Bruxelles;

Prof. Dr. jur. H.M. **Oeftering** (2), Vorsitzer des Vorstandes und Erster Präsident der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

G. **Olivier** (2), Administrateur de l'Office National pour l'achèvement de la Jonction Nord-Midi; 26, avenue Milcamps, Bruxelles;

A. **Plana** (already named);

J. **Puig Batet** (3), Directeur du Réseau National des Chemins de fer espagnols; Madrid;

J. **Ratter** (1), Technical Adviser, British Transport Commission; 222, Marylebone Road, London, N.W.1;

P. **Renaud** (1), Vice-Président du Conseil d'administration de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IX^{e});

Dr. Ing. S. **Rissone** (2), Directeur Général des Chemins de fer italiens de l'Etat; Rome;

General Sir Brian **Robertson** (already named);

Dr.-Ing. E. **Roscioni** (2), Inspecteur Général Supérieur de la Motorisation Civile et des Transports concédés au Ministère des Transports (Italie), Rome;

H. **Saito** (3), Directeur du Département Etranger aux Chemins de fer Nationaux du Japon; Chiyodaku Tokio;

Dj. **Savičević** (3), Directeur Général Adjoint des Chemins de fer Yougoslaves; Belgrade;

Dr M. **Schantl** (1), Directeur Général des Chemins de fer fédéraux autrichiens; 9, Elisabethstrasse, Vienne I;

Dr. F. **Schelp** (1), Mitglied des Vorstandes und Präsident der Deutschen Bundesbahn; Friedrich-Ebert-Anlage, 43-45, Frankfurt (Main);

H.E. **Simpson** (2), President, Baltimore and Ohio Railroad Company; Baltimore, Md.;

P.E.N. **Skov** (1), Directeur Général des Chemins de fer de l'Etat danois; 40, Sölvgade, Copenhague, K;

R. **Soulard** (1), Directeur du Mouvement de la Société Nationale des Chemins de fer français; 8, rue de Londres; Paris (IX^{e});

H.E. **Stokke** (3), Directeur Général des Chemins de fer de l'Etat norvégien; Oslo;

J. **Tuja** (2), Secrétaire Général de l'Union internationale des Chemins de fer; 10, rue de Prony, Paris;

E.G.J. **Upmark** (3), Directeur Général des Chemins de fer de l'Etat suédois; Stockholm;

R. **Vaubourdolle** (3), Chef Adjoint des Installations Fixes de la Société Nationale des Chemins de fer français; 42, rue de Châteaudun, Paris;

F. Perez **Villamil** (3), Directeur Adjoint du Réseau National des Chemins de fer espagnols; Madrid;

W. **White** (1), President, Delaware & Hudson Railroad Corporation; 230, Park Avenue, New York 17;

O. **Wichser** (2), Directeur Général, Chef du Département des Travaux et de l'Exploitation des Chemins de fer Fédéraux Suisses; Berne;

Dr. Ing. W. **Wyrzykowski** (2), Vice-Directeur de l'Institut Scientifique des Essais et des Recherches Ferroviaires des Chemins de fer de l'Etat Polonais; Varsovie;

N..... (3) Argentina.
N..... (1) Argentina.
N..... (3) Bulgaria.
N..... (3) China.
N..... (1) Egypt.
N..... (3) Spain.
N..... (2) U.S.A.
N..... (3) Roumania.
N..... (3) Switzerland.

(1) Retires at the 18th session.
(2) Retires at the 19th session.
(3) Retires at the 20th session.

Honorary President : F.H. **Delory,** Directeur Général honoraire de la Société Nationale des Chemins de fer belges; 2, avenue Curé Glibert, Rixensart.

Members of Honour : L. **Armand,** ancien Président du Conseil d'administration de la Société Nationale des Chemins de fer français; 88, rne Saint-Lazare, Paris (IX^{e})

O.V.S. **Bulleid,** former Chief Mechanical Engineer, Coras Iompair Eireann, and former Chief Mechanical Engineer, Southern Region, British Railways; St. Anthony's Close, Belstone, Devon.

P. **Ghilain,** Directeur honoraire du Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges, Secrétaire Général de l'Association; 19, rue du Beau-Site, Bruxelles.

Ranald J. **Harvey,** Consulting Engineer; 34, Victoria Street, Westminster, London, S.W.1.

The Rt. Hon. Lord **Hurcomb,** G.C.B., K.B.E., Chairman, British Transport Commission 1947-53; 47, Campden Hill Court, Campden Hill Road, Kensington, London W. 8.

U. **Lamalle,** Directeur Général honoraire de la Société Nationale des Chemins de fer belges, professeur émérite de l'Université de Louvain; 27, rue de l'Aurore, Bruxelles.

SECRETARY'S OFFICE : 19, rue du Beau-Site, Brussels.

General Secretary : **P. Ghilain** (already named).

LIST OF PARTICIPANTS

TO THE NEW DELHI MEETING.

* Members of the Permanent Commission.

** Assistants to members of the Permanent Commission.

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* A. **Brouckaert,** Directeur du Service du Matériel et des Achats de la Société Nationale des Chemins de fer Belges.

* Dr.-Ing. A. **Cuttica,** Directeur Général Adjoint et Conseiller d'Administration des Chemins de fer Italiens de l'Etat.

** M. **Martinelli,** Inspecteur en Chef Supérieur au Service de la Traction des Chemins de fer Italiens de l'Etat.

* M. **De Vos,** Directeur Général de la Société Nationale des Chemins de fer Belges, Président de l'Association Internationale du Congrès des Chemins de fer.

* P. **Ghilain,** Directeur Honoraire du Service du Matériel et des Achats de la Société Nationale des Chemins de fer Belges, Secrétaire Générale de l'Association Internationale du Congrès des Chemins de fer et Membre d'Honneur de la Commission Permanente.

* K. W. C. **Grand,** Member, British Transport Commission.

** S. B. **Warder,** Chief Electrical Engineer, British Transport Commission.

* Dr. H. **Gschwind,** Président de la Direction Générale des Chemins de fer Fédéraux Suisses.

* F. **Hebert,** Directeur Général Adjoint de la Société Nationale des Chemins de fer Français.

** M. **Garreau,** Chef Adjoint du Matériel et de la Traction de la Société Nationale des Chemins de fer Français.

* I. A. **Ivanov,** Directeur de l'Institut Scientifique des Chemins de fer de l'U.R.S.S.

** V. R. **Ptentsov,** Représentant du Ministère des Chemins de fer de l'U.R.S.S.

* Dipl.-Ing. M. **Jacobshagen,** Ministerialdirektor, Leiter der Betriebsabteilung in der Hauptverwaltung der Deutschen Bundesbahn.

* Brig. Ch. A. **Langley,** Chief Inspecting Officer of Railways, Ministry of Transport and Civil Aviation (Grande-Bretagne).

* Ir. J. **Lohmann,** Président des Chemins de fer Néerlandais.

** Ir. J. P. **Koster,** Directeur Général des Chemins de fer Néerlandais.

* P. **Nolet de Brauwere,** Secrétaire Général Honoraire de la Société Nationale des Chemins de fer Belges.

* Prof. Dr. Jur. H. M. **Oeftering,** Vorsitzer des Vorstandes und Erster Präsident der Deutschen Bundesbahn.

** G. **Wiens,** Direktor bei der Hauptverwaltung der Deutschen Bundesbahn.

* Dr.-Ing. E. **Roscioni,** Inspecteur Général Supérieur de la Motorisation Civile et des Transports concédés au Ministère des Transports (Italie).

** L. **Pratesi,** Inspecteur Supérieur au Ministère des Transports (Italie).

* Dr. M. **Schantl,** Directeur Général des Chemins de fer Fédéraux Autrichiens.

* H. **Saito,** Directeur du Département Etranger aux Chemins de fer Nationaux du Japon. *(Excused.)*

** H. **Shima,** Chief Engineer, Member of the Board of Directors (Japanese National Railways).

** U. **Matsuda,** Deputy Director, Foreign Department (Japanese National Railways).

** N. **Fukuzaki,** Deputy Director, Rolling Stock, Design Office (Japanese National Railways).

** T. **Mizumo,** Electrical Department, Electrification Section (Japanese National Railways).

** Mr. **Kuroiwa,** Secrétaire de l'Ambassade du Japon (New-Delhi).

* E. G. J. **Upmark,** Directeur Général des Chemins de fer de l'Etat Suédois. *(Excused.)*

** A. **Karsberg,** Chief Electrical Engineer, Chemins de fer de l'Etat Suédois.

* R. **Vaubourdolle,** Chef Adjoint des Installations Fixes de la Société Nationale des Chemins de fer Français.

** F. **Nouvion,** Ingénieur en Chef à la Division des Etudes de Traction Electrique de la Direction du Matériel et de la Traction de la Société Nationale des Chemins de fer Français.

LOCAL SECRETARIAT OF ORGANISATION.

Secretary :

D. **Kumar,** Joint Director Research, Design and Standardisation Organisation.

REPORTERS.

J. J. **Jonker,** Chef du Service du Matériel Roulant et des Installations Electriques des Chemins de fer Néerlandais.

Ing. K. **von Meyenburg,** Premier Chef de Section de la Division de la Traction et des Ateliers, Chemins de fer Fédéraux Suisses.

BUREAU OF SECTION II.

Locomotives and Rolling Stock.

President :

A. **Brouckaert,** Directeur du Service du Matériel et des Achats de la Société Nationale des Chemins de fer Belges.

Principal Secretary :

R. **Squilbin,** Ingénieur Principal à la Société Nationale des Chemins de fer Belges, Secrétaire Technique de l'Association.

SECRETARIAT OF THE PERMANENT COMMISSION :

F. **Baeyens,** Ingénieur en Chef à la Société Nationale des Chemins de fer Belges, Secrétaire Technique de l'Association.

J. **Dumont,** Chef du Secrétariat.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Enlarged Meeting of the Permanent Commission, held in New Delhi

(7th to 9th December 1959).

Summary of sectional proceedings.

SECTION II. — Locomotives and rolling stock.

[621 .335]

QUESTION 2.

Problems met in the design of multi-current rolling stock. Existing types : experimental results. Future developments.

Preliminary documents.

Report *(Western Germany, North and South America, South Africa, Australia, Burma, Ceylon, Egypt, Ghana, India, Indonesia, Iran, Irak, Republic of Ireland, Japan, Norway, New-Zealand, Pakistan, Netherlands, Philippines, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories, Sudan, Sweden, and the Union of Socialist Soviet Republics)*, by J. J. JONKER (See *Bulletin* for October 1959, p. 929).

Report *(Austria, Belgium and Belgian Congo, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Greece, Hungary, Italy, Lebanon, Luxemburg, Poland, Portugal and Overseas Territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Viet-Nam and Yugoslavia)*, by K. VON MEYENBURG (See *Bulletin* for October 1959, p. 961.)

Special Report, by J.J. JONKER (See *Bulletin* for November 1959, p. 1017.)

DISCUSSION BY THE SECTION.

Meeting of the 7th December 1959 (afternoon).

President : A. Brouckaert, *Manager of the Rolling Stock and Stores Department of the Belgian National Railways, Member of the Permanent Commission of the Association.*

— The meeting began at 2.15 p.m.

The President welcomed the Delegates and thanked the Indian Railways for their kind hospitality. He stressed the importance and topicality of the problem to be discussed during the present meeting, the extension of the electrification of the various railways resulting in more cases of lines electrified under different systems coming into contact with each other.

Mr. Squilbin *(Principal Secretary)*, then read certain written communications, sent by certain Members of the Permanent Commission who were unable to attend the meeting, to the Secretariat in connection with the summaries given in paragraph 9 of the Mr. Jonker's special report:

— Messrs. Born *(Union d'Entreprises Suisses de Transport)*, Branca *(Chemins de fer de l'Etat Italien*, Clarembaux, Crem *(Société Nationale des Chemins de fer Belges)*, Dunbar *(British Transport Commission)*, Garcia-Lomas *(Réseau National des Chemins de fer Espagnols)*, Geitmann *(Deutsche Bundesbahn)*, Kriz *(Ministère des Communications, Tchécoslovaquie)*, Musquar *(Société Nationale des Chemins de fer Luxembourgeois)*, Rissone *(Chemins de fer de l'Etat Italien)* and Svagel *(Chemins de fer Yougoslaves)* had no comments to make about the proposed summaries;

— Sir Brian Robertson and Mr. Ratter *(British Transport Commission)*, were of the same opinion as Messrs. Grand and Warder who were present at the meeting;

— Mr. Dargeou *(Société Nationale des Chemins de fer Français)*, pointed out that the S.N.C.F. delegates present at the meeting would explain the stand taken by this Administration on this point;

— Messrs. Bulleid *(Member of Honour of the Permanent Commission)*, de Aguinaga *(Réseau National des Chemins de fer Espagnols)*, Loomis *(Association of American Railroads)*, Modlinksi *(Ministère des Communications, Pologne)* and Villamil *(Réseau National des Chemins de fer Espagnols)* made certain comments which will be referred to when discussing the summaries in question.

The President then opened the discussions on the proposed summaries.

Summary No. 1 :

1. Multi-current motive power units are power units which can work with more than one type of current.

   Such units are already in operation, or under construction, in the following combinations :

   (*a*) D.C. systems of different voltages;

   (*b*) A.C. systems of different voltages but the same frequency;

(*c*) A.C. systems of different voltages and frequencies;

(*d*) one or more A.C. systems and one or more D.C. systems;

(*e*) one three-phase current system and one D.C. system.

— *As no comments were made, Summary No. 1 is adopted.*

Summary No. 2 :

2. Multi-current motive power units for D.C. systems of different voltages are characterized by the following features :

(*a*) Compared with motive power units exclusively designed for the highest voltage concerned :

— there must be a possibility of combining the motors in parallel instead of in series;

— there must be a possibility of connecting the auxiliaries, inasmuch as they are fed from the catenary, in parallel instead of in series, which calls for a division of the auxiliary power;

(*b*) Compared with motive power units exclusively designed for the lowest voltage concerned :

— in addition to the features mentioned under (*a*), it is necessary to provide the traction motors, the high-tension cabling and those auxiliaries fed directly from the catenary with an insulation adequate for the highest voltage.

Only where the highest voltage happens to be a whole multiple of the lowest voltage it is possible to use connection schemes which enable the motive power unit to develop its full power with both voltages.

Mr. KARSBERG *(Swedish State Railways)* considered that the last paragraph of the summary was too restrictive. He pointed out, for example, that in the case of a power unit taking a 1 kV and 1.5 kV supply, different couplings of the motors (3×2 and 2×3 respectively) made it possible to make full use of the full power of the motor. He suggested modifying this paragraph as follows : « the use of the full power of the multicurrent power unit at all voltages is only possible if such voltages are whole multiples of the voltage of the motor. »

Mr. JONKER *(Special Reporter)* pointed out that the admissible voltages were laid down (Report No. 48 of the 1955 International Electrotechnical Committee) as 600, 750, 1 200, 1 500, 2 400, and 3 000 V. The hypothesis mentioned by Mr. KARSBERG could not therefore be realised in practice, and he suggested that the original text be retained.

Mr. WARDER *(British Transport Commission)* supported Mr. KARSBERG's proposal, to leave the way clear for the future.

Mr. JONKER finally came round to this opinion, so that the PRESIDENT stated that the final paragraph of Summary No. 2 would be modified as suggested by Mr. KARSBERG.

Mr. KOSTER *(Netherlands Railways)* suggested completing the 1st paragraph under *a*) of the summary (« there must be a possibility of combining the motors in parallel instead of in series ») by « either singly or in groups. »

After an exchange of opinions in which Messrs. JONKER, VON MEYENBURG *(Reporter)*, GARREAU and NOUVION *(Société Nationale des Chemins de fer Français)* took part, it was agreed, as suggested by Mr. GARREAU that this paragraph would be reworded as follows : « there must be a possibility of providing supplementary combinations for the traction motors. »

Mr. MARTINELLI *(Italian State Railways)* considered that the wording of the 2nd paragraph under *a*) of the summary excluded the possibility of using motors with two collectors. After a discussion in which Messrs. JONKER, NOUVION and WARDER took part, the President suggested that the end of this paragraph be worded as follows: « ...which may call either for a division of the auxiliary power, or for the use of motors with two collectors. »

The text of Summary No. 2, adopted with these different amendments, becomes :

« 2. Multi-current motive power units for D.C. systems of different voltages are characterized by the following features :

« *a*) Compared with motive power units exclusively designed for the highest voltage concerned :

« — there must be a possibility of providing supplementary combinations for the traction motors;

« — there must be a possibility of connecting the auxiliaries, inasmuch as they are fed from the catenary, in parallel instead of in series, which may call either for a division of the auxiliary power, or for the use of motors with two collectors;

« *b*) Compared with motive power units exclusively designed for the lowest voltage concerned :

« in addition to the features mentioned under *a*), it is necessary to provide the traction motors, the high-tension cabling and those auxiliaries fed directly from the catenary with an insulation adequate for the highest voltage.

« The use of the full power of the multi-current power unit at all the voltages is only possible if these voltages are whole multiples of the motor voltage.

Summary No. 3 :

3. Multi-current motive power units for A.C. systems of different voltages but the same frequency are characterized by the following features :

(*a*) Compared with motive power units exclusively designed for the highest voltage concerned :

— it is necessary to adapt the transformer primary :

— either by dividing the primary winding into groups and connecting these in parallel instead of in series;

— or by means of a tapping on the primary circuit, so arranged that the secondary voltage remains the same.

If it is desired to have the full power available at both voltages, the former method is only applied if the highest voltage is a whole multiple of the lowest voltage. With the second method, on the other hand, it is always possible to obtain the desired tapping provided that the primary windings are suitably reinforced.

Moreover, the second method permits of speed regulation on the high-tension side;

(*b*) Compared with motive power units exclusively designed for the lowest voltage concerned :

— in addition to the features mentioned under (*a*), it is necessary to provide the transformer primary, the pantographs, the pneumatic circuit breaker and the cabling between these components with an insulation adequate for the highest voltage.

Mr. KARSBERG suggested modifying the first sentence of the second paragraph under *a*) of this summary as follows : « ... the first method can only be used if both are whole multiples of the voltage of the primary winding used. »

Mr. WARDER preferred the original text. The other Delegates agreeing with him, the summary is adopted in its original form.

Summary No. 4 :

4. Multi-current motive power units for A.C. systems of different voltages and frequencies may be equipped :

(*a*) either with A.C. motors;

(*b*) or with undulating current motors.

In the latter case, it is necessary to increase the size of the transformer, to an extent which depends on the rectifier connection scheme. Though more complicated, and not normally used on low-frequency motive power units designed for one type of current only, this solution is still the one most commonly adopted if the motive power unit must also work with A.C. of higher frequency.

In the former case (A.C. motors), the multi-current motive power units are characterized by the following features :

(*a*) (1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :

— to enlarge the copper cross-section of the primary transformer windings;

— to enlarge the section of the magnetic core;

— to provide for the possibility of modifying the degree of interpole shunting;

— to provide switch-over facilities for the tertiary transformer winding, used for current supply to the auxiliaries;

(*a*) (2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned, it is necessary :

— to insulate the transformer primary for the highest voltage;

— to subdivide the transformer windings to a greater extent in order to reduce the leakage at the highest frequency;

— to provide for the possibility of modifying the degree of interpole shunting;

— to provide switch-over facilities for the tertiary transformer winding.

In the second case (undulating current motors), the multi-current motive power units are characterized by the following features :

(*b*) (1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :

— to enlarge the copper cross-section of the primary transformer windings;

— to enlarge the section of the magnetic core;

— to adapt the rectifier ignition coils for the lowest frequency;

— to provide switch-over facilities for the tertiary transformer winding;

(*b*) (2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned (and equipped with A.C. traction motors) :

— in addition to the features listed under (*a*) (2) above;

— traction motors for undulating current are most commonly used.

Mr. NOUVION pointed out that the factors of comparison between equipment with A.C. motors and equipment with undulating current motors, which are the subject of the 2nd paragraph of the summary (« In the latter case, it is... »)

are incomplete, as they only deal with the dimensions of the transformers and not those of the motors. Moreover, in connection with the use of the undulating current motor on low frequency engines, he pointed out that the Pennsylvanian Railroad has just ordered for its 25 cycles system, 66 locomotives with ignitrons, intended to replace its old locomotives with single phase motors. Considering therefore that the statements made in this 2nd paragraph are rather too restricted in character, he suggested suppressing it and including these factors in the following summaries.

Mr. von Meyenburg was not against Mr. Nouvion's suggestion, but pointed out that if only the dimensions of the transformer and not those of the motors were quoted, this was because here we were more specially concerned with the influence of the coupling of the rectifiers on the transformer. As for the motors, their weight does not vary, whether the motive power unit is a multicurrent one or not.

The suggestion made by Mr. Nouvion, supported moreover by Messrs. Garreau, Jonker and Warder, is approved.

To introduce the principles defined in this way, Mr. Nouvion suggested the following text for paragraph *a* 1) of the summary :

« *a* 1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :

as far as the transformer is concerned :

— to enlarge the copper cross-section of the primary windings;

— to enlarge the section of the magnetic core;

— to provide switch-over facilities for the tertiary windings used for current supply to the auxiliaries;

the first two requirements listed above lead in practice to the weight being doubled if the same power is to be retained;

as far as the traction motors are concerned:

— to provide for the possibility of modifying the degree of interpole shunting; »

Mr. von Meyenburg stated that, without precising the frequencies considered, it was difficult to estimate the increase in weight of the transformer.

Mr. Nouvion agreed that the sentence in question should be suppressed.

— *Paragraph a* 1*) was adopted in this latter form.*

Mr. Nouvion suggested the following text for paragraph *a* 2) :

a 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned, it is necessary :

as far as the transformer is concerned :

— to insulate the primary for the highest voltage;

— to subdivide the windings to a greater extent in order to reduce the leakage at the highest frequency;

— to provide switch-over facilities for the tertiary transformer winding;

as far as the traction motors are concerned:

— to use traction motors designed for working at the highest frequency. »

Mr. VON MEYENBURG considered it necessary to precise that it must also be possible to modify the degree of shunting of the auxiliary poles.

Messrs. NOUVION and WARDER expressed their agreement with this, *and paragraph a 2) is adopted with this amendment.*

Mr. NOUVION proposed the following text for paragraph *b* 1) :

« *b* 1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :

as far as the transformer is concerned, and besides the particularities mentioned under *a* 1) for the transformer :

— to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;

as far as the traction motors are concerned:

— to give up A.C. traction motors, in the less frequent case when the power unit at the highest frequency was fitted with this type of motor ».

Mr. VON MEYENBURG suggested retaining the text concerning the ignition coils of the rectifiers.

Mr. GARREAU considered that in this case it would also be necessary to mention a lot of other equipment, which would have a bad effect on the clarity of a text which already was very long.

After Messrs. JONKER and VON MEYENBURG had agreed with this point of view, *paragraph b 1) is adopted in the form suggested by* Mr. NOUVION.

Mr. NOUVION suggested the following text for paragraph *b* 2) :

« *b* 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned (and equipped with A.C. traction motors), it is necessary :

as far as the transformer is concerned, and besides the particularities mentioned under *a* 2) for the transformer :

— to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;

as far as the traction motors are concerned:

— to give up the A.C. traction motors in the most frequent case when the power unit at the lowest frequency and the lowest voltage was fitted with this type of motor. »

Mr. VON MEYENBURG agreed, but proposed stressing the fact that the use of an undulating current motor means using rectifiers, which normally are not used on power units supplied at the lowest voltage and frequency.

Mr. NOUVION, whilst considering this precision a rather superfluous one, saw no drawback in including it in the text.

Leaving this point unsettled, the PRESIDENT stated that the final text of this

paragraph, would be revised by the Office and submitted to the Assembly at the next session, and adjourned the meeting at 4.30 p.m.

Meeting of the 8th December 1959.

President : A. Brouckaert.

The meeting began at 9.15 a.m.

The President asked Mr. Squilbin to read the text of paragraph *b* 2) of Summary No. 4, which had been held over from the previous meeting.

« *b* 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned (and equipped with A.C. traction motors), it is necessary :

as far as the transformer is concerned, and besides the particularities mentioned under *a* 2) for the transformer :

— to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;

as far as the traction motors are concerned:

— to give up the A.C. traction motors in the most frequent case when the power unit at the lowest frequency and the lowest voltage was fitted with this type of motor;

— to introduce rectifiers in the equipment.

As no comments were made about this text, the President *declared it approved.*

The final text of Summary No. 4 is therefore as follows :

« 4. Multi-current motive power units for A.C. systems of different voltages and frequencies may be equipped :

a) either with A.C. motors;

b) or with undulating current motors.

« In the former case (A.C. motors), the multi-current motive power units are characterized by the following features :

« *a* 1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :

« as far as the transformer is concerned :

« — to enlarge the copper cross-section of the primary windings;

« — to enlarge the section of the magnetic core;

« — to provide switch-over facilities for the tertiary windings used for current supply to the auxiliaries;

« as far as the traction motors are concerned :

« — to provide for the possibility of modifying the degree of interpole shunting;

« *a* 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned, it is necessary :

« as far as the transformer is concerned :

« — to insulate the primary for the highest voltage;
« — to subdivide the windings to a greater extent in order to reduce the leakage at the highest frequency;
« — to provide switch-over facilities for the tertiary transformer winding;
« as far as the traction motors are concerned :
« — to use traction motors designed for working at the highest frequency;
« — to provide for the possibility of modifying the degree fo interpole shunting;

« In the second case (undulating current motors) the multi-current motive power units are characterized by the following features :

« *b* 1 Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :
« as far as the transformer is concerned, and besides the particularities mentioned under *a* 1) for the transformer :
« — to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;
« as far as the traction motors are concerned :
« — to give up A.C. traction motors, in the less frequent case when the power unit at the highest frequency was fitted with this type of motor;

« *b* 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned (and equipped with A.C. traction motors), it is necessary :
« as far as the transformer is concerned, and besides the particularities mentioned under *a* 2) for the transformer :
« — to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;
« as far as the traction motors are concerned :
« — to give up the A.C. traction motors in the most frequent case when the power unit at the lowest frequency and the lowest voltage was fitted with this type of motor;
« — to introduce rectifiers in the equipment. »

Summary No. 5. :

5. Multi-current motive power units for one or more A.C. systems and one or

more D.C. systems are always equipped with rectifiers. The speed can be controlled :

— on the A.C. side;

— on the D.C. side;

— at the rectifiers, if these are equipped with grids.

Speed regulation on the A.C. side or at the rectifiers gives rise to additional complication of the equipment. D.C. regulation increases the cost of energy consumed.

Multi-current motive power units of this category are characterized by the following features :

(*a*) Compared with motive power units exclusively designed for A.C. of the highest voltage and frequency concerned :

— in addition to the features listed under (*b*) (1) of Summary No. 4, it is necessary :

— to adopt construction devices permitting current collection (for the stationary train as well as the running train) and speed regulation on D.C. lines;

— to use D.C. traction motors which, being insulated for the highest D.C. voltage to be taken into account, must be heavier than with A.C. motors;

— to install appropriate circuit breakers and starting resistances equipped with the necessary contactors;

— to use auxiliaries which, inasmuch as they are also required for D.C. working, must be designed for D.C. and must, on A.C. lines, be fed through rectifiers.

The elimination of speed control on the A.C. side or at the rectifiers may also be envisaged.

(*b*) Compared with motive power units exclusively designed for A.C. of the lowest voltage and frequency concerned, it is necessary :

— to resort to rectifier equipment, as the possibility of designing motive power units capable of working on 1 500 V D.C. lines with motors also suited for A.C. feed is merely academic;

— to enlarge the size of the transformer, as mentioned in Summary No. 4.

In addition, when working on D.C. lines, these motive power units must have the same features as under (*a*) above;

(*c*) Compared with motive power units exclusively designed for D.C. of the highest voltage concerned, it is necessary :

— when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter (*a*);

— when working on A.C. lines, to install a transformer, an air circuit breaker and rectifiers to feed the traction circuits and auxiliaries;

(*d*) Compared with motive power units exclusively designed for D.C. of the lowest voltage concerned, it is necessary :

— when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter (*b*);

— when working on A.C. lines, to rely on the same measures as those listed under (*c*) above.

Before the discussions on this text began, Mr. Squilbin pointed out that the English text of the 3rd paragraph of this summary should be reworded as follows :

« to use D.C. traction motors, whose insulation, adapted to the highest D.C. voltage to be taken into account, must be reinforced compared with A.C. motors ».

Mr. Squilbin also read a written comment about Summary No. 5 received from Mr. Modlinski, who pointed out that compared with the technical complications caused by the regulation on the A.C. side or rectifiers, losses of energy for the

regulation on the D.C. side are of no importance, and consequently, preference should be given to the latter method of regulation.

In connection with the same point, Mr. GARREAU commented that losses of current, in the case of regulation on the D.C. side, depend essentially on the service worked by the engine.

Mr. VON MEYENBURG, for his part, considered that it would be better to speak of «consommation d'énergie» rather than « dépense d'énergie ».

After an exchange of opinions in which Messrs. WARDER and JONKER also took part, it was agreed to modify the text as follows : D.C. regulation increases the energy consumption to an extent which is moreover variable with the nature of the service. »

Returning to the first sentence of the summary, Mr. SHIMA (*Japanese National Railways*) remarked that the J.N.R. at the present time are building a locomotive whose motors can be supplied directly either with D.C. or A.C. and this is being done to make regenerative braking easier. He therefore considered that the word « always » could not be used in this sentence.

Mr. JONKER suggested replacing « always » by « most frequently ». *(Agreed.)*

As regards the various methods of regulating the speed, Mr. GARREAU considered that the alternatives quoted only concerned working with A.C., as with D.C. the regulation of the speed always takes place by rheostat and modification of the coupling of the motors. He therefore suggested to make it clear in the text : « Regulating the speed *with A.C.* can be carried out... »

Mr. VON MEYENBURG pointed out that on the 25001/25009 locomotives of the S.N.C.F., the regulation of the speed with D.C. took place on the A.C. side, but he proposed to esclude this special case, which in fact came within the framework of Summary No. 9. *(Agreed.)*

Mr. MARTINELLI suggested suppressing, in the case of regulating the speed with rectifiers, the words « if they are fitted with grids » in view of present developments in rectifier technique.

Mr. WARDER thought that it was not advisable to be too precise in a field where numerous technical details are still in the experimental stage, and in agreement with Mr. NOUVION, he suggested simply saying : « at the rectifiers, if they permit it ». *(Agreed.)*

Mr. SHIMA pointed out that the question of picking up the current, raised in paragraph *a*) of this summary, also concerned paragraphs *b*, *c* and *d*. He suggested therefore that this point should be referred to the introduction to the summary which is of a general character.

Mr. JONKER reported that the difficulties of picking up the current are greater with D.C. than with A.C. Mentioning this in paragraph *a*) stressed this difference. He considered however that this question could be treated in Summary No. 7 dealing with the pantographs. *(Agreed.)*

As regards paragraph *b*) of the summary,

taking into account the statements previously made by the representatives of the J.N.R. as well as the equipment in use on the New York Central, Mr. Nouvion suggested modifying the text of the first paragraph, as follows :

« — most frequent use of rectifier equipment ». *(Agreed.)*

In paragraph *c* of the summary, Mr. Nouvion suggested suppressing the word « air », as all the circuit breakers used are not necessarily of this type. *(Agreed.)*

— *In view of these various amendments, the final text of Summary No. 5 becomes :*

« 5. Multi-current motive power units for one or more A.C. systems and one or more D.C. systems are most frequently equipped with rectifiers. On A.C. systems the speed can be controlled :

« — on the A.C. side;

« — on the D.C. side;

« — at the rectifiers, if they permit it.

« Speed regulation on the A.C. side or at the rectifiers gives rise to additional complication of the equipment. D.C. regulation increases the energy consumption to an extent which is moreover variable with the nature of the service.

« Multi-current motive power units of this category are characterized by the following features :

« *a*) Compared with motive power units exclusively designed for A.C. of the highest voltage and frequency concerned :

in addition to the features listed under *b* 1) of Summary No. 4, it is necessary;

« — to adopt construction devices permitting speed regulation on D.C. lines;

« — to use D.C. traction motors whose insulation adapted to the highest D.C. voltage to be taken into account must be reinforced compared with A.C. motors;

« — to install appropriate circuit breakers and starting resistances equipped with the necessary contactors;

« — to use auxiliaries which, inasmuch as they are also required for D.C. working must be designed for D.C. and must, on A.C. lines, be fed through rectifiers.

« The elimination of speed control on the A.C. side or at the rectifiers may also be envisaged;

« *b*) Compared with motive power units exclusively designed for A.C. of the lowest voltage and frequency concerned :

« — most frequent use of rectifier equipment;

« — increase of the size of the transformer, as mentioned in Summary No. 4.

« In addition, when working on D.C. lines, these motive power units must have the same features as under *a*) above;

« *c*) Compared with motive power units exclusively designed for

D.C. of the highest voltage concerned, it is necessary :

« — when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter *a*);

« — when working on A.C. lines, to install a transformer, a circuit breaker and rectifiers to feed the traction circuits and auxiliaries;

« *d*) Compared with motive power units exclusively designed for D.C. of the lowest voltage concerned, it is necessary :

« — when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter *b*);

« — when working on A.C. lines, to rely on the same measures as those listed under *c*) above. »

Summary No. 6. :

6. In the only reported case of D.C. motive power units being adapted to working with three-phase current, a three-phase transformer and rectifiers have been provided to feed the traction motors and auxiliaries when working on A.C. lines.

The suggested text which refers to the Italian practice did not completely satisfy Mr. MARTINELLI. He stressed the fact that the multicurrent vehicles under consideration are not « suitable » for working with three-phase current, but that it is a question of ordinary D.C. vehicles which are to be run on three-phase current. He suggested the following text which was adopted :

« 6. In the only reported case of D.C. motive power units which must also work with three-phase current, a three-phase transformer and rectifiers have been provided; those permit the working of the traction motors and auxiliaries on A.C. lines, without any alteration. »

Summary No. 7 :

7. To enable motive power units to work on lines with different types of current, they may have to be equipped with one or more additional pantographs, depending on the networks on which they are to run, unless the dimensions of the collector bow can be completely standardized.

Mr. SQUILBIN read some comments made in connection with Summary No. 7 :

— Messrs. DE AGUINAGA and VILLAMIL insisted on the value of standardising the pantographs;

— Mr. LOOMIS reported that the A.A.R. Study Committee recommends that not more than 2 pantographs be fitted on a locomotive.

Mr. VON MEYENBURG recognised the value of standardising pantographs, but stressed the difficulties such standardisation came up against, especially in view of the differences there often were on the one hand in the neutral sections of the systems concerned, and on the other hand in the installation of their catenaries. He also recalled that as Summary No. 5 no longer dealt with picking up the current, the differences existing between picking up the current with D.C. and A.C. should be stressed in this Summary. He suggested inserting a paragraph about this point,

which would mention in particular the difference there is the contact pressure.

Mr. Baeyens *(Société Nationale des Chemins de fer Belges)* supported Mr. von Meyenburg. As a member of an O.R.E. Committee of Experts responsible for studying the standardisation of pantographs, he reported that up to the present no complete standardisation is possible. In addition to the problems already mentioned, the width of the pantograph and the contact pressure, there is a third : the nature of the friction strips.

Mr. Jonker pointed out that the J.N.R. have successfully standardised the pantographs of their D.C. and A.C. stock.

Mr. Karsberg considered that the difficulties of the problem in question should be stressed in this summary; he suggested modifying the text of the summary as follows : « ... according to the networks on which they are to run, unless the dimensions and pressure conditions of the collector bow can be completely standardised. »

Mr. Warder suggested it would be better to say : « the dimensions of the collector bow and the performances... »

This latter formula was generally approved.

The final text of Summary No. 7 therefore becomes :

« 7. To enable motive power units to work on lines with different types of current, they may have to be equipped with one or more additional pantographs, depending on the networks on which they are to run, unless the dimensions of the collector bow and the performances can be completely standardized. »

Summary No. 8 :

8. It is desirable to provide, on multicurrent motive power units, either a protection device preventing the wrong choice of system, or a wholly automatic system selection device.

Brig. Langley *(Ministry of Transport and Civil Aviation, Great Britain)* was happy to see a summary which dealt with the question of protective devices. He considered it would be useful to insist still more upon safety and suggested adding the following text to the summary :

« Particular attention should always be paid to safety and protective devices should be provided to assure that changing over from one system of current to another takes place without danger, either to the passengers or to the staff, nor to the installations themselves. Any defects in the changeover system must always be on the side of safety. »

Messrs. Jonker and von Meyenburg fully appreciated the interest of the remark made by Brig. Langley. However, they considered that it was not exclusive to multicurrent power units and they wondered whether this being so, it was in the right place in this particular summary.

Mr. Karsberg also agreed with Brig. Langley. He was of the opinion, however, that the problem he raised is such an important one that it should be studied on its own at a future meeting of the Congress.

Brig. LANGLEY signified his agreement with this, and said he was ready to withdraw his suggested amendment if the question could be included in the agenda for a future meeting of the Congress.

The PRESIDENT took note of this statement; he said that in the near future, the Secretariat of the Congress would ask Members of the Permanent Commission to put forward their suggestions regarding the points to be included on the agenda for the 1962 Congress. He asked Brig. LANGLEY to put forward his suggestion on that occasion. *(Agreed.)*

Mr. KOSTER asked for a more precise wording for the summary, as it was not a question of the choice of a system but of the connection in an adequate manner of the traction equipment to the feeding system. He suggested the following wording for the Summary, which was *adopted :*

« 8. It is desirable to provide, on multicurrent motive power units, either a protection device preventing the connection of the feeding system to a wrong traction coupling or a wholly automatic traction equipment selection device. »

Summary No. 9 :

9. In all cases, where it is not necessary to obtain the full power with all the types of current concerned, the various conditions outlined above may be relaxed or even ignored, and other solutions might also be adopted.

As no comments were made, Summary No. 9 was adopted.

Summary No. 10 :

10. It is less difficult to base the design of a multi-current motive power unit on that of a unit designed for the highest voltage and frequency concerned, than on the design of a unit designed for the lowest voltage and frequency concerned, or for D.C.

Mr. NOUVION pointed out that the matter was different according to whether it was a question of altering existing monocurrent units or of designing new multicurrent units. He also drew attention to the multiplicity of the systems already in use, 6 for A.C. of various frequencies and 6 for D.C., and wondered whether there was consequently any hope of arriving at a general summary, especially in view of the multiple combinations possible. Therefore, he suggested that this summary be suppressed. *(Agreed.)*

Summary No. 11 (new No. 10).

11. Multi-current motive power units are more complicated, and therefore more costly, than motive power units designed for one type of current only.

The application of such units is therefore reduced as much as possible.

In consequence, the numbers of such vehicles for which orders are placed are comparatively small, and this fact tends to increase the price still further.

Mr. CUTTICA *(Italian State Railways)* suggested combining the last two paragraphs by saying : « For this reason, the numbers ordered are limited to the strict minimum and remain small, which is another reason for higher prices. »

Mr. WARDER remarked that in certain cases, the installation of multicurrent units may be justified by important savings

on the fixed installations. He suggested adding the following text to the summary : « In certain cases, however, such equipment can be justified for reasons of economy or operating. »

Mr. Jonker thought that this idea was included in summaries Nos. 14 and 15.

Mr. Garreau was afraid that the comment made by Mr. Warder, a comment which in fact was directed especially to the particular case of double voltage working, 25 kV and 6.25 kV, used on the British Railways, might lead readers astray when included in a summary of a general nature.

To take these comments into account, Mr. von Meyenburg suggested amending slightly the text of the summary, as follows: « For this reason, the numbers ordered are *normally limited...* » *(Approved).*

The text duly modified becomes :

« 10. Multi-current motive power units are more complicated, and therefore more costly, than motive power units designed for one type of current only.

Therefore, the numbers of such vehicles for which orders are placed, are normally limited to the number needed and remain small; this fact tends to increase the price still further. »

Summary No. 12 (new No. 11) :

12. Owing to their complexity, the cost of maintaining the electrical parts of multi-current motive power units is higher than with units designed for one type of current only. This applies the more, the greater the number of different types of current for which the unit is designed.

However, as the total maintenance cost is largely governed by the maintenance of the mechanical parts, an increase in the cost of maintaining the electrical parts will not have a major incidence on the total maintenance cost.

— As no comments were made, Summary No. 12 was adopted as the new Summary No. 11.

Summary No. 13 (new No. 12) :

13. In view of the fact that the first cost and maintenance cost of multi-current motive power units are higher than those of units designed for one type of current only, preference should be given to the alternative solution of changing locomotives at the transition station, wherever this solution is compatible with operating conditions.

Mr. Squilbin advised the meeting of a written comment in connection with Summary No. 13 received from Mr. Loomis who reports that in the U.S.A., it is not considered economic to use monocurrent engines in a transition station with two voltages, owing to the high labour costs.

— As no other comments were made, Summary No. 13 was adopted in its original form as new Summary No. 12.

Summary No. 14 (new No. 13) :

14. Where the change of motive power units is not compatible with operating conditions, e.g. because :
   — the transition stations would become too complicated, or
   — it is desired to work through trains without changing locomotives, or
   — it is desired to obviate the need for passengers to change from one railcar or multiple-unit train to another, or

— it is necessary to have regard to the shunting movements at stations equipped for more than one type of current;

multi-current motive power units must be used.

The technical feasibility is demonstrated by vehicles already in service.

Before the discussions on this text began, Mr. SQUILBIN reported that the English text should be modified as follows: (2nd paragraph) : « the transition stations are complicated, »

Mr. SQUILBIN also advised the Meeting of a written comment from Mr. BULLEID who pointed out that the improved operating conditions due to electrification should make it possible to change locomotives without difficulty at all transition points.

— As no other comments were made, Summary No. 14 was adopted in its original form, as the new No. 13.

Summary No. 15 (new No. 14) :

15. If operating requirements permit, it is advisable, for economic reasons, to design the multi-current motive power units, with one type of current, working at reduced power.

This solution is acceptable if the working of the motive power units is confined to short runs to and from the transition stations to reach the station of the adjoining railway system equipped with one type of current only.

Before the discussions on this text began, Mr. SQUILBIN reported that the English text should be modified as follows (2nd paragraph) : « ... to short runs *over the transition points* to reach... »

Mr. WARDER remarked that the map appended to Mr. VON MEYENBURG's report shows that operating conditions will make it necessary to build multi-current engines which can work at full power under all systems of current. Consequently, he wondered if Summary No. 15 was well founded.

Mr. JONKER replied that this summary develops ideas already expressed in Summary No. 9. In addition, such arrangements exist and should be mentioned, especially as they result in less costly solutions.

Mr. WARDER said he was satisfied with these explanations.

— As no further comments were made, Summary No. 15 was adopted in its original form, as the new No. 14.

* * *

The PRESIDENT thanked all the Delegates for their collaboration in order to arrive at concrete summaries. He was especially grateful to Mr. JONKER, *Special Reporter* and Mr. VON MEYENBURG, *Reporter*, for the remarkable work of synthesis they had presented.

Mr. JONKER in his own name and on behalf of Mr. VON MEYENBURG thanked the PRESIDENT for his tribute to them; in his turn, he wished to thank the PRESIDENT for the way he had directed the work of the Section.

Mr. CUTTICA, in the name of all the Delegates, seconded Mr. JONKER.

(Great applause.)

— The meeting rose at 12.45.

* * *

— The Summaries adopted by the Section were submitted to the Plenary Meeting of the Permanent Commission of the 9th. December 1959, and ratified without any modification.

The complete and final text is given hereafter :

SUMMARIES.

1. Multi-current motive power units are power units which can work with more than one type of current.

   Such units are already in operation, or under construction, in the following combinations :

   a) D.C. systems of different voltages;

   b) A.C. systems of different voltages but the same frequency;

   c) A.C. systems of different voltages and frequencies;

   d) one or more A.C. systems and one or more D.C. systems;

   e) one three-phase current system and one D.C. system.

2. Multi-current motive power units for D.C. systems of different voltages are characterized by the following features :

   a) Compared with motive power units exclusively designed for the highest voltage concerned :

   — there must be a possibility of providing supplementary combinations for the traction motors;

   — there must be a possibility of connecting the auxiliaries, inasmuch as they are fed from the catenary, in parallel instead of in series, which may call either for a division of the auxiliary power, or for the use of motors with two collectors;

   b) Compared with motive power units exclusively designed for the lowest voltage concerned :

   in addition to the features mentioned under *a*), it is necessary to provide the traction motors, the high-tension cabling and those auxiliaries fed directly from the catenary with an insulation adequate for the highest voltage.

   The use of the full power of the multi-current power unit at all the voltages is only possible if these voltages are whole multiples of the motor voltage.

3. Multi-current motive power units for A.C. systems of different voltages but the same frequency are characterized by the following features :

   a) Compared with motive power units exclusively designed for the highest voltage concerned :

   it is necessary to adapt the transformer primary :

   — either by dividing the primary winding into groups and connecting these in parallel instead of in series;

   — or by means of a tapping on the primary circuit, so arranged that the secondary voltage remains the same.

   If it is desired to have the full power available at both voltages, the former method is only applied if the highest volt-

age is a whole multiple of the lowest voltage. With the second method, on the other hand, it is always possible to obtain the desired tapping provided that the primary windings are suitably reinforced.

Moreover, the second method permits of speed regulation on the high-tension side;

b) Compared with motive power units exclusively designed for the lowest voltage concerned :
in addition to the features mentioned under *a*), it is necessary to provide the transformer primary, the pantographs, the circuit breaker and the cabling between these components with an insulation adequate for the highest voltage.

4. Multi-current motive power units for A.C. systems of different voltages and frequencies may be equipped :
a) either with A.C. motors;
b) or with undulating current motors.

In the former case (A.C. motors), the multi-current motive power units are characterized by the following features :

a 1) Compared with motive power units exclusively designed for the highest voltage and frequency concerned, it is necessary :
as far as the transformer is concerned :
— to enlarge the copper cross-section of the primary windings;
— to enlarge the section of the magnetic core;
— to provide switch-over facilities for the tertiary windings used for current supply to the auxiliaries;
as far as the traction motors are concerned :
— to provide for the possibility of modifying the degree of interpole shunting;

a 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned, it is necessary :
as far as the transformer is concerned :
— to insulate the primary for the highest voltage;
— to subdivide the windings to a greater extent in order to reduce the leakage at the highest frequency;
— to provide switch-over facilities for the tertiary transformer winding;
as far as the traction motors are concerned :
— to use traction motors designed for working at the highest frequency;
— to provide for the possibility of modifying the degree of interpole shunting;

In the second case (undulating current motors) the multi-current motive power units are characterized by the following features :

b 1) Compared with motive power units exclusively designed for

the highest voltage and frequency concerned, it is necessary :

as far as the transformer is concerned, and besides the particularities mentioned under *a* 1) for the transformer:

— to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;

as far as the traction motors are concerned :

— to give up A.C. traction motors, in the less frequent case when the power unit at the highest frequency was fitted with this type of motor;

b 2) Compared with motive power units exclusively designed for the lowest voltage and frequency concerned (and equipped with A.C. traction motors), it is necessary :

as far as the transformer is concerned, and besides the particularities mentioned under *a* 2) for the transformer :

— to increase the dimensions of the transformer in order to take into account the feeding of the motors through rectifiers; this increase is moreover function of the rectifiers combination;

as far as the traction motors are concerned :

— to give up the A.C. traction motors in the most frequent case when the power unit at the lowest frequency and the lowest voltage was fitted with this type of motor;

— to introduce rectifiers in the equipment.

5. Multi-current motive power units for one or more A.C. systems and one or more D.C. systems are most frequently equipped with rectifiers.

On A.C. systems the speed can be controlled :

— on the A.C. side;

— on the D.C. side;

— at the rectifiers, if they permit it.

Speed regulation on the A.C. side or at the rectifiers gives rise to additional complication of the equipment.

D.C. regulation increases the energy consumption to an extent which is moreover variable with the nature of the service.

Multi-current motive power units of this category are characterized by the following features :

a) Compared with motive power units exclusively designed for A.C. of the highest voltage and frequency concerned :

in addition to the features listed under *b* 1) of Summary No. 4, it is necessary;

— to adopt construction devices permitting speed regulation on D.C. lines;

— to use D.C. traction motors whose insulation adapted to the highest D.C. voltage to be taken into account must be reinforced compared with A.C. motors;
— to install appropriate circuit breakers and starting resistances equipped with the necessary contactors;
— to use auxiliaries which, inasmuch as they are also required for D.C. working, must be designed for D.C. and must, on A.C. lines, be fed through rectifiers.

The elimination of speed control on the A.C. side or at the rectifiers may also be envisaged;

b) Compared with motive power units exclusively designed for A.C. of the lowest voltage and frequency concerned :
— most frequent use of rectifier equipment;
— increase of the size of the transformer, as mentioned in Summary No. 4.

In addition, when working on D.C. lines, these motive power units must have the same features as under *a*) above;

c) Compared with motive power units exclusively designed for D.C. of the highest voltage concerned, it is necessary :
— when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter *a*);
— when working on A.C. lines, to install a transformer, a circuit breaker and rectifiers to feed the traction circuits and auxiliaries;

d) Compared with motive power units exclusively designed for D.C. of the lowest voltage concerned, it is necessary :
— when working on D.C. lines, to rely on the same measures as those listed in Summary No. 2, letter *b*);
— when working on A.C. lines, to rely on the same measures as those listed under *c*) above.

6. In the only reported case of D.C. motive power units which must also work with three-phase current, a three-phase transformer and rectifiers have been provided; those permit the working of the traction motors and auxiliaries on A.C. lines, without any alteration.

7. To enable motive power units to work on lines with different types of current, they may have to be equipped with one or more additional pantographs, depending on the networks on which they are to run, unless the dimensions of the collector bow and the performances can be completely standardized.

8. It is desirable to provide, on multi-current motive power units, either a protection device preventing the connection of the feeding system to a wrong traction coupling or a wholly automatic traction equipment selection device.

9. In all cases, where it is not necessary to obtain the full power with all the types of current concerned, the various conditions outlined above may be relaxed or even ignored, and other solutions might also be adopted.

10. Multi-current motive power units are more complicated, and therefore more costly, than motive power units designed for one type of current only.

    Therefore, the numbers of such vehicles for which orders are placed, are normally limited to the number needed and remain small; this fact tends to increase the price still further.

11. Owing to their complexity, the cost of maintaining the electrical parts of multi-current motive power units is higher than with units designed for one type of current only. This applied the more, the greater the number of different types of current for which the unit is designed.

    However, as the total maintenance cost is largely governed by the maintenance of the mechanical parts, an increase in the cost of maintaining the electrical parts will not have a major incidence on the total maintenance cost.

12. In view of the fact that the first cost and maintenance cost of multi-current motive power units are higher than those of units designed for one type of current only, preference should be given to the alternative solution of changing locomotives at the transition station, wherever this solution is compatible with operating conditions.

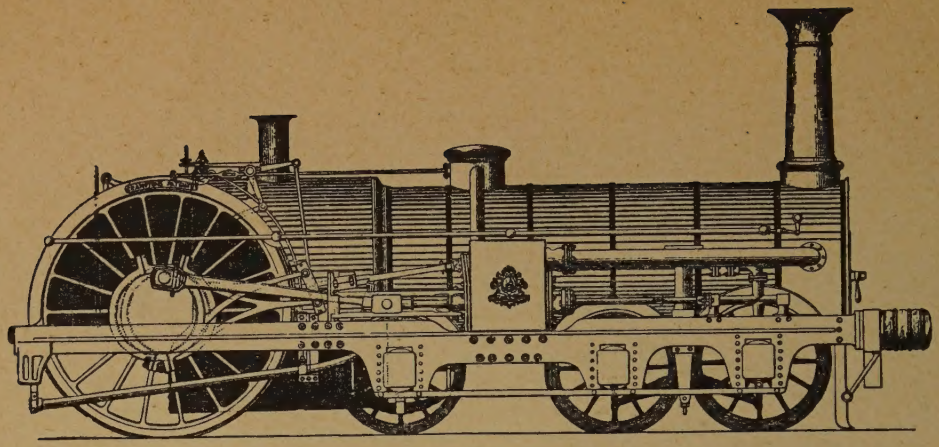
13. Where the change of motive power units is not compatible with operating conditions, e.g. because :
    - — the transition stations are complicated, or
    - — it is desired to work through trains without changing locomotives, or
    - — it is desired to obviate the need for passengers to change from one railcar or multiple-unit train to another, or
    - — it is necessary to have regard to the shunting movements at stations equipped for more than one type of current;

    multi-current motive power units must be used.

    The technical feasibility is demonstrated by vehicles already in service.

14. If operating requirements permit, it is advisable, for economic reasons, to design the multi-current motive power units with one type of current working at reduced power.

    This solution is acceptable if the working of the motive power units is confined to short runs over the transition points, to reach the station of the adjoining railway system equipped with one type of current only.



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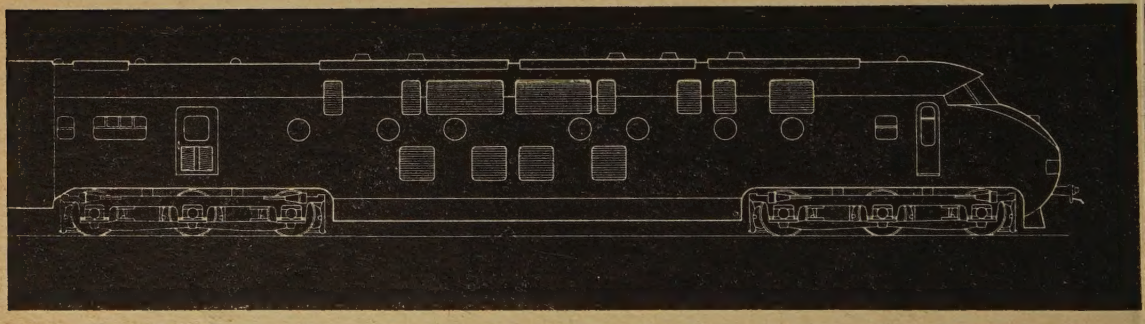

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